Vol. 90, No. 3 September, 1961

The Philippine Journal of Science

QUEZON CITY
BUSTAMANTE PRESS, INC.
1961

THE PHILIPPINE JOURNAL OF SCIENCE

Published quarterly by the National Institute of Science and Technology (Formerly Bureau of Science), P. O. Box 774, Manila, Philippines

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 90 SEPTEMBER, 1961 No. 3

STUDIES ON THE SEASONAL DISTRIBUTION OF PHYTOPLANKTON OF TADLAK LAKE, LOS BAÑOS, LAGUNA, LUZON ISLAND, PHILIPPINES*

BY ARACELI B. GONZALES[1]

THREE PLATES AND NINE TEXT FIGURES

Of the numerous factors that affect phytoplankton distribution, the climatic factors evidently undergo seasonal and annual changes. For the past five years, preliminary observations based on unpublished data (Velasquez, C.C.) showed changes in phytoplankton distribution in Tadlak Lake on certain selected dates. Because of these observations, studies were made for a year from December 18, 1955 to November 25, 1956 in order to determine the seasonal distribution of some phytoplankton in Tadlak Lake (Alligator Lake), Los Baños, Laguna Province, Luzon Island in correlation with certain environmental factors.

Our knowledge of Philippine fresh-water plankton is fragmentary. Shaw(28) reported four genera and six species of the Volvocaceæ from the Pasig River and certain seasonal and temporary pools in the vicinity of Manila. Taylor(33) described three new species of the genus *Anabænopsis* from phytoplankton of Sampaloc Lake, Laguna.

The recent investigations of G.T. Velasquez(36–40) included a good number of Philippine phytoplankton especially those be-

* Paper based from the author's thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Botany, University of the Philippines, 1958.

[1] The author was aided by her co-advisers, Carmen C. Velasquez and Gregorio T. Velasquez, in preparing her paper in its present form, and wishes to thank them here for their most valuable help.

longing to the Myxophyceæ. Soriano and Velasquez(32) described six genera of phytoplankton with notes on the ecological and seasonal distribution. Drouet and Daily(9) in their revision of the coccoid group included six planktonic species from the Philippines.

Woltereck(46) furnished data on certain Philippine lakes including that of Tadlak Lake in Los Baños, Laguna, but was limited in scope.

The present investigation is an attempt to supply the notable lack of significant data on phytoplankton and their seasonal distribution in Philippine lakes.

METHODS OF INVESTIGATION

Morphometric data were obtained from measurements of an enlarged photograph of Hydrographic Map No. 95, Philippine Coast and Geodetic Survey. From this map the area, the maximum limnological and geographical length and width, the length of the shore line and the shore development were computed (Table 1 and Fig. 1). A line graduated in meters with a Kemmerer's sampler attached to one end served not

TABLE 1.—*Morphometric data in Tadlak Lake.*

	Meters	Feet
Maximum length (limnological)	700	2296.00
Maximum length (geographical)	700	2296.00
Maximum width (limnological)	515	1689.20
Maximum width (geograhical)	515	1689.20
Maximum depth	65	213.20
Length of shore line	1925	6314.00
Area—square meters	270,000	
Direction of main axis	NE—SW	
Shore development		1.04

only as weight but also for the collection of bottom water samples and determination of maximum depth. Owing to limited facilities, soundings and total volume determination were not done.

Collections of plankton samples and observations were made at monthly intervals for a period of one year.

To determine the limit of visibility (light penetration), monthly Secchdisk readings were made only at the middle of the lake from 11:00 a.m. to 12:30 p.m. (Table 2); surface and subsurface monthly temperature readings were made from 9:00 to 12:00 noon and later followed by plankton collections.

TABLE 2.—*Limit of visibility readings in Tadlak Lake from December 18, 1955 to November 25, 1956.*

	Dec. 18	Jan. 22	Mar. 11	Apr. 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 26	Nov. 25
Readings in feet	3.0	2.75	3.25	4.75	5.0	8.6	9.75	4.75	5.75	3.75	3.25

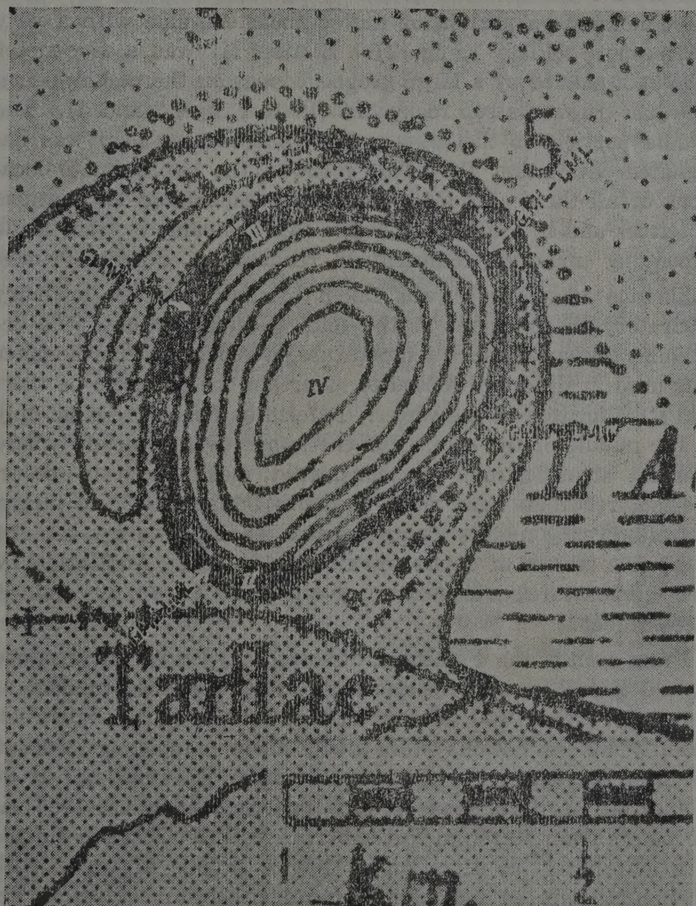


Fig. 1. An enlarged picture of Tadlak Lake in Los Baños, Laguna reproduced from the Hydrographic Map No. 95 of the Philippine Geodetic Survey showing the paths of the four dimensional lines of the geographical maximum length and width and the limnological maximum length and width. These paths are indicated by arrows where they touch the shoreline with symbols LML, GML, LMW, and GMW.

For chemical analysis, samples of surface water were taken from each of the four stations chosen on the basis of certain features of the lake which were considered likely to be subjected to seasonal physico-chemical changes. Designated as Station I was a shallow spot, one and a half feet deep on the northeast side of the lake. This portion developed a shore less than a meter wide (Plate 1, fig. 1). Station II was a three-meter deep portion of the southeastern side with a very rocky shore (Plate 1, fig. 2). Station III was a five-meter deep spot shaded by a large group of trees on the northwestern side just below a steep rocky hill (Plate 1, figs. 3 and 4). The middle portion of the lake at sixty-one meters deep was designated as Station IV. Fig. 1 shows the approximate locations of all these stations with the corresponding designations in letters and in arabic numerals. Vertical samples were made depending upon the temperature readings at different times.

Surface temperature was taken by means of an ordinary laboratory thermometer at the four selected stations. To determine the sub-surface temperature, a reversing thermometer was used at different depths to ascertain the presence of thermal stratification in the water. Determinations were done only at the middle of the lake. For the upper twenty meters where thermal stratification was considered most likely to occur, thermal readings were made at depth intervals of one meter. Beyond twenty meters deep, thermal readings were taken for every five meters of depth down to the bottom. At Station IV the temperature determinations were limited to 30 and 60 meters deep.

From each of the 4 stations, dissolved oxygen was determined by the Rideal-Stewart modification of the Winkler method as given by Welch.(45) Methyl orange and phenolphthalein alkalinity determinations were made from samples at Station IV from December 18, 1955 to November 25, 1956 and at 30 meters on April 15, May 19, July and September 23, 1956; at 61 meters from March to November. Presence of carbon dioxide was determined by titration of 100 cc sample of water with phenolphthalein as indicator. Hydrogen-ion concentration determination was made by the use of a colorimetric device, the La Motte comparator. Reserve hydrogen-ion concentration was also included in the chemical analysis of the water.

The alkaline pH values obtained were quite significant to require analysis. Samples collected from Station IV were kept in 120 cc glass-stoppered bottles for several months before phenolphthalein and methyl orange alkalinity determinations.

Both horizontal and vertical qualitative and quantitative phytoplankton analyses were made.

For the qualitative analysis, surface collections of phytoplankton were obtained by means of an ordinary plankton net (No. 20 mesh) towed by a banca around the lake. Samples were divided into two lots and kept in 60 cc wide-mouthed jars which were labeled accordingly. One lot was brought back to the laboratory for examination; the other lot was preserved in 5 per cent formalin solution. Since microscopic examination was not possible in the field, all the identifications of the fresh specimens were made in the laboratory a day after each collection. Verification of the identifications were done at later dates on the preserved specimens.

Vertical qualitative phytoplankton identifications were made on samples obtained with a 1200-cc Kemmerer sampler and concentrated with a Wisconsin plankton net (horizontal mesh 80 per inch, vertical mesh 98 per inch). Identifications were made only from preserved specimens.

Phytoplankton identification records were kept for all the monthly collections. Illustrations were done with the aid of a camera lucida under oil immersion objective from fresh and preserved specimens. Photomicrographs of a few species were made from preserved specimens only under oil immersion objective. A taxonomic list and description of all phytoplankton found in the lake was made, tychoplankters included.

For the quantitative analysis, samples of the water were taken with a pail of 2.5 liter capacity from the four stations for surface phytoplankton counts. From three to five pails were concentrated with a Wisconsin plankton net to from 50 to 100 cc. Depending upon the physico-chemical features of the water, vertical phytoplankton samplings were made. One to two hauls were obtained and concentrated to 50 cc. All the concentrates for qualitative analysis were preserved in 3 to 5 per cent formalin solution in wide-mouthed bottles.

Analysis of the preserved phytoplankton concentrates were done in the laboratory at the earliest convenience. Differential

generic counts and total counts of the more common phytoplankton were made with the use of a Sedgewick-Rafter counting chamber and a Whipple micrometer ocular. Counts were made by the random sampling method per cubic millimeter of the concentrate. From three to five trials were considered satisfactory. All the counts were made under the low power objective with a 10x eyepiece. Since specific identification of all the individuals is not possible by this method, species counts were not done. From the results obtained the number of phytoplankters per liter of original water was computed. Monthly tabulations of the phytoplankton counts were made. The quantitative variations of the phytoplankton during the different months are expressed in organisms per liter and represented in tables and in graphs.

DESCRIPTION OF LAKE

Tadlak Lake is approximately two kilometers west of the town of Los Baños and lies close to the shores of Laguna de Bay. As stated in the Census of the Philippines (1903) the lake is of volcanic origin, resulting from the formation of secondary centers of activity of the Mount Makiling Volcano. The exact date of its formation is not given but it has been known to exist long before the American conquest. It has often been referred to as Alligator Lake presumably due to the presence of alligators although no evidence of their existence is available. Records show that crocodiles did exist in the lake as early as the 1920's but have since then disappeared.

The lake has a maximum geographical and limnological length of 700 meters; width of 515 meters and a maximum depth of 65 meters located at a spot a little to the south of the middle of the lake. The area as computed from the above named Hydrographic Map No. 95 is 270,000 sq. m. or 27 hectares. Length of shoreline is 1,925 meters. Table 1 gives a summary of all the available morphometric data of Tadlak Lake.

The lake lies in a deep basin with a declivitous bank except for a small portion on the north and northeast sides (Plate 2, figs. 5 and 6). Littoral vegetation is very scarce, except for a few patches of grass on the north side. Surrounding the lake, is a dense growth of trees on top of the hills, some practically overhanging the water on the northwestern side (Plate 2, figs. 7 and 8). A small ring-shaped hill of calcareous nature shields

the area on its west border (Plate 2, fig. 8). On the north, south and east sides are also slight elevations of the same calcareous material. Protection from too much wind action thus afforded is significant to the lake. Wave action in its waters is not as great as that of the more exposed adjacent Laguna de Bay.

The lake has no visible inlets and outlets and is probably fed by underground springs. The only surface inflow of water, is that coming from the surrounding slopes after heavy rains. Water level was found to increase slightly after the start of the rainy season. Although no actual measurements were made on a water level gauge, the water level at the time of collection was etched and measured on a submerged buttress root in the southwestern portion of the lake. An increase of nine inches was found between the start of the rains in May and the start of the dry season after October.

RESULTS AND DISCUSSIONS

Limit of visibility readings are summarized in Table 2. Light penetration was found to be the least on December 18, 1955 and January 22, 1956 and the greatest on June 19, July 29, 1956.

Monthly surface temperature readings at all the stations are summarized in Table 3. During the entire period of investigation surface temperature range showed no marked variations, changes being only from 27.5°C on December 18, 1955 to 30°C on January 22, April 15, and May 19, 1956.

Vertical temperature readings show that the lake is nearly homothermous. A gradual decrease in temperature exists from the surface waters to the bottom as shown in Table 4. The vertical temperature gradients are illustrated in Fig. 5.

TABLE 3.—*Summary of the surface physico-chemical compositions in Tadlak Lake from December 18, 1955 to November 25, 1956.*

STATION I

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
pH	8.2	8.2	8.4	8.2	8.4	8.4	8.4	8.0	8.0	8.2	8.2
rpH	8.2	8.2	8.4	8.2	8.4	8.4	8.4	8.0	8.0	8.2	8.2
O_2p.p.m.	3.6	4.0	3.6	5.0	5.8	4.0	3.2	3.4	3.2	3.5	3.4
CO_2p.p.m.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phenolph. alk. ppm.	—	—	—	—	—	—	—	—	—	—	—
M.O. alk. ppm.	—	—	—	—	—	—	—	—	—	—	—
Temperature °C	27.5	30.0	28.8	30.0	30.0	29.5	29.0	29.0	29.0	29.0	28.5

STATION II

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
pH	8.2	8.2	8.4	8.2	8.4	8.4	8.4	8.0	8.0	8.2	8.2
rpH	8.2	8.2	8.4	8.2	8.4	8.4	8.4	8.0	8.0	8.2	8.2
O_2p.p.m.	3.6	4.0	3.6	5.0	6.0	3.6	3.8	3.8	3.4	3.6	3.4
CO_2p.p.m.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phenolph. alk. ppm.	—	—	—	—	—	—	—	—	—	—	—
M.O. alk. ppm.	—	—	—	—	—	—	—	—	—	—	—
Temperature °C	27.5	30.0	28.8	30.0	30.0	29.5	29.0	29.0	29.0	29.0	28.5

STATION III

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
pH	8.2	8.2	8.4	8.2	8.4	8.4	8.4	8.0	8.0	8.2	8.2
rpH	8.2	8.2	8.4	8.2	8.4	8.4	8.4	8.0	8.0	8.2	8.2
O_2p.p.m.	3.6	4.0	3.6	5.0	5.0	4.0	4.0	3.8	3.4	3.6	3.6
CO_2p.p.m.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phenolph. alk. ppm.	—	—	—	—	—	—	—	—	—	—	—
M.O. alk. ppm.	—	—	—	—	—	—	—	—	—	—	—
Temperature °C	27.5	30.0	28.8	30.0	30.0	29.5	29.0	28.5	29.0	29.0	28.5

STATION IV

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
pH	8.2	8.2	8.4	8.2	8.4	8.4	8.4	8.0	8.0	8.2	8.2
rpH	8.2	8.2	8.4	8.2	8.4	8.4	8.4	8.0	8.0	8.2	8.2
O_2p.p.m.	3.6	4.0	3.6	5.0	4.9	3.5	4.0	3.6	3.8	3.6	3.4
CO_2p.p.m.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phenolph. alk. ppm.	16.0	18.0	23.0	18.0	27.0	25.0	21.0	15.0	15.0	20.0	20.0
M.O. alk. ppm.	268.0	283.0	293.0	270.0	308.0	290.0	283.0	283.0	291.0	285.0	290.0
Temperature °C	27.5	30.0	28.6	30.0	30.0	29.5	29.0	29.0	29.0	29.0	28.5

Dissolved oxygen at the surface was found to be present in relatively small amounts, the highest recorded being 5 parts per million on May 19, 1956, the lowest recorded 3.32 parts per million on June 19, 1956. Table 3 shows the results of the dissolved oxygen tests at the surface and the monthly variations are shown in Fig. 2. Dissolved oxygen tests at 30 meters deep and at 61 meters deep are shown in Table 4. Fig. 3 shows the monthly variations at these depths.

Concentrations of dissolved oxygen were found to be a little lower at a depth of 30 meters and at the bottom than at the surface within the limitations of the methods used. The entire

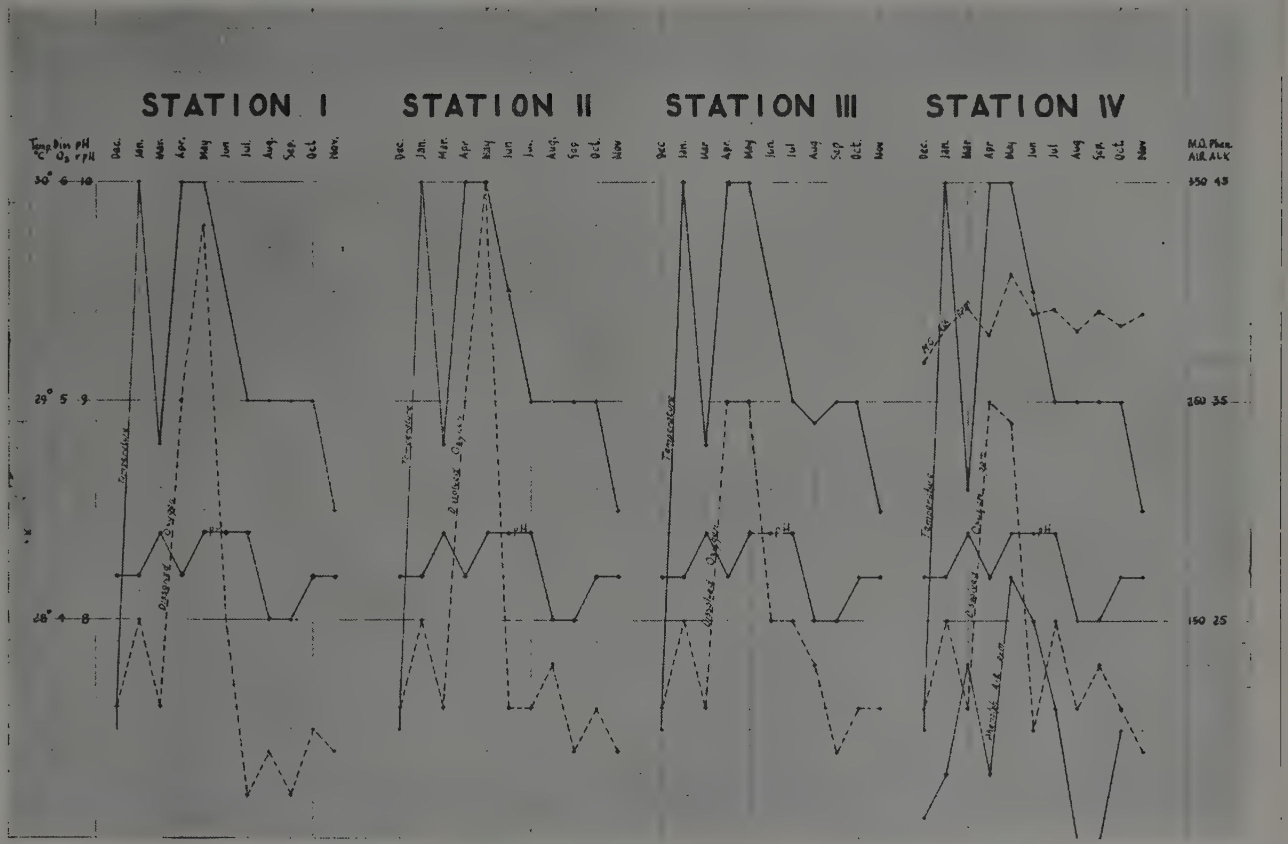


FIG. 2. *Variations of surface physico-chemical conditions in Tadlak Lake from December 18, 1955 to November 25, 1956.*

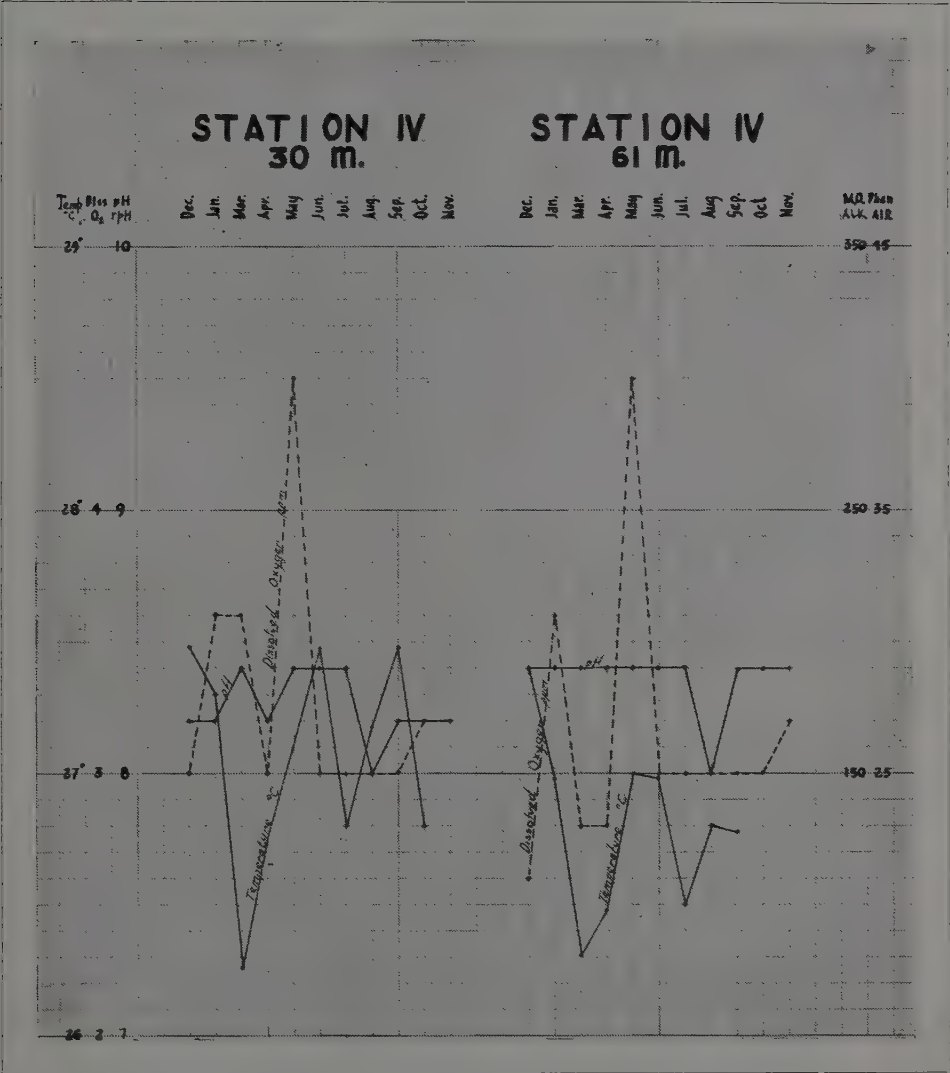


FIG. 3. *Seasonal variations in physico-chemical conditions at 30 m and at 61 m in Tadlak Lake from December 18, 1955 to November 25, 1956.*

TABLE 4.—*Summary of the physico-chemical conditions in Tadlak Lake at thirty meters and sixty-one meters deep from December 18, 1955 to November 25, 1956.*

STATION IV (THIRTY METERS DEEP)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
pH	8.2	8.2	8.4	8.2	8.4	8.4	8.4	8.0	8.2	8.2	8.2
rpH	8.2	8.2	8.4	8.2	8.4	8.4	8.4	8.0	8.2	8.2	8.2
O_2p.p.m.	3.0	3.6	3.6	3.0	4.5	3.0	3.0	3.0	3.0	3.2	3.2
CO_2p.p.m.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phenolph. alk. ppm.	—	—	—	22.0	26.0	—	22.0	—	20.0	—	—
M.O. alk. ppm.	—	—	—	290.0	300.0	—	290.0				
Temperature °C	27.49	27.30	26.28	26.78	27.19	27.49	26.80	27.19	27.49	26.80	—

STATION IV (SIXTY-ONE METERS DEEP)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
pH	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.0	8.4	8.4	8.4
rpH	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.0	8.4	8.4	8.4
O_2p.p.m.	2.6	3.6	2.8	2.8	4.5	3.0	3.0	3.0	3.0	3.0	3.2
CO_2p.p.m.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phenolph. alk. ppm.	—	—	23.0	22.0	22.0	23.0	22.0	25.0	23.0	23.0	23.0
M.O. alk. ppm.	—	—	293.0	296.0	290.0	290.0	290.0	295.0	295.0	295.0	294.0
Temperature °C	27.39	26.99	24.30	26.48	27.0	26.99	26.50	28.8	26.79	26.49	—

basin of the lake seems to have a fair amount of dissolved oxygen throughout the entire year.

The amount of oxygen from the lower depth needs explanation. It is hoped that future investigations should include nitrogen (nitrate and nitrite) analysis not considered in the present paper. The presence of a high concentration of nitrites at the bottom may be possible being one of the products of decay; if so, it may affect oxygen tests.

Free carbon dioxide was not detected either on the surface or at 30 meters deep and at the bottom during all the observations. If any free carbon dioxide was present in the water it seems that it was present only in amounts too small to be detected by means of the NaOH nitration method.

Methyl orange and phenolphthalein were used in the determination of alkalinity. Samples were obtained at Station IV from December 18, 1955 to November 25, 1956 and at 30 meters on April 15, May 19, July 29, and September 23, 1956 only. At 61 meters determinations were done from March to Novem-

ber. From the results obtained (Tables 3 and 4, and Fig. 3), phenolphthalein alkalinity was at its lowest during August and September, being only 15 parts per million. The highest value recorded was 27 parts per million on May 19, 1956. Methyl orange alkalinity followed the same pattern of phenolphthalein alkalinity, the lowest being 268 parts per million on December 18, 1955 reaching 308 parts per million on May 19, 1956.

Phenolphthalein alkalinity at 30 meters deep was found to be similar to that of the surface during May and July. A slight increase was noted in April and September. Generally, phenolphthalein and methyl orange alkalinity were slightly higher at the bottom than at the surface or at 30 meters deep. The phenolphthalein and methyl orange alkalinity at the bottom at 61 meters is rather marked. All alkalinity determinations were made several months after the samples were collected.

All the phytoplankton (euplankton or tychoplankton) found during the observations are included in the following list:

I. Myxophyceæ
Chroococcales
Chroococcaceæ

Anacystis cyanea Drouet and Daily
Anacystis thermalis fo. *thermalis* Drouet and Daily
Anacystis dimidiata Drouet and Daily

Oscillatoriales
Oscillatorineæ
Oscillatoriaceæ

Spirulina princeps (West & West) G. S. West
Spirulina major Kützing
Oscillatoria amphibia C. A. Agardh
Oscillatoria tenuis C. A. Agardh
Phormidium minnesotense (Tilden) Drouet
Lyngbya meneghiniana Gomont

Nostochineæ
Nostocaceæ

Anabaena variabilis Kützing
Anabaenopsis circularis (G. S. West) Miller
Calothrix parietina (Naegeli) Thuret

II. Chlorophyceæ
Chlorococcales
Oöcystaceæ

Tetraedron muticum (A. Braun) Hansgrig
Tetraedron minimum (A. Braun) Hansgrig
Planktosphaeria sp. G. M. Smith

Oedogoniales
Oedogoniaceæ

Oedogonium sp. Link

Cladophorales
Cladophoraceæ

Cladophora sp. Kützing

III. Bacillariophyceæ
Pennales
Fragillarineæ

Fragillaria sp. Lyngbye

Naviculineæ

Navicula sp. Bory
Mastogloia sp. Thwaites
Cymbella sp. C. A. Agardh
Epithemia sp. Brebisson

A taxonomic key and description of species is herein presented:

1. Plants with pigments diffused in protoplasm .... I. Myxophyceæ
1. Plants with pigments in plastids 2
   2. Color of pigments green .... II. Chlorophyceæ
   2. Color of pigments golden brown .... III. Bacillariophyceæ

I. MYXOPHYCEÆ

Plants typically blue-green, pigments diffuse in protoplasm; unicellular or multicellular; reproduction always asexual either by simple cell division or by means of hormogonia.

Key to the genera

1. Plant colonial .... 1. *Anacystis*
1. Plant filamentous 2
   2. Trichomes without heterocysts 3
   2. Trichomes with heterocysts 6
3. Trichomes without evident sheath 4
3. Trichomes with evident sheath 5
   4. Trichomes spirally twisted .... 2. *Spirulina*
   4. Trichomes straight or slightly bent but not spirally twisted. 3. *Oscillatoria*
   Sheaths very thin .... 4. *Phormidium*
5. Sheaths regularly wide .... 5. *Lyngbya*
   6. Heterocysts intercalary .... 6. *Anabæna*
   6. Heterocysts terminal at both ends of the trichomes. 7. *Anabænopsis*
   6. Heterocyst basal, trichomes tapering from base to apex. 8. *Calothrix*

1. Genus ANACYSTIS Meneghini, 1837

ANACYSTIS CYANEA Drouet and Daily. Plate 3, fig. 9.

Anacystis cynanea DROUET and DAILEY, Butler Univ. Bot. Stud. 10

Colonies spherical, ovoid, or irregularly lobed with a colorless, hyaline, gelatinous matrix. Cells distinctly blue-green, from 2.7 to 5 micra in diameter, somewhat spherical or oval, very much crowded.

ANACYSTIS THERMALIS fo. THERMALIS Drouet and Daily. Plate 3, fig. 10.

Anacystis thermalis fo. *thermalis* DROUET and DAILY, Butler Univ. Bot. Stud. 12 (1956) 77, 12 (1956) 77–83, figs. 114–129.

Cells more or less spherical, usually hemispherical for some time after division, commonly united in two-celled colonies. Cells from 2.8 to 4.5 micra broad, bright blue-green. Sheath homogenous or lamellose, colorless.

ANACYSTIS DIMIDIATA Drouet and Daily. Plate 3, fig. 11.

Anacystis dimidiata DROUET and DAILY, Butler Univ. Bot. Stud. 10 (1952) 221, 12 (1956) 70–75, figs. 100–107.

Cells spherical or oblong-ellipsoid, usually hemispherical for some time after division; united in colonies of frequently 2 to 4 by distension of the sheath of the parent cell. Sheath colorless, lamellate. Diameter of cells from 8.5 to 15 micra. Cell contents blue-green, homogenous.

2. Genus SPIRULINA Turpin, 1827

SPIRULINA PRINCEPS (West and West) G. S. West. Plate 3, fig. 12.

Spirulina princeps (West and West) G. S. WEST (1907) 179; PRESCOTT, Cranbr. Inst. Sci. Bull. 31 (1951) 481, Plate 108, fig. 13; SMITH, (1950) 573–574, fig. 485b.

Trichomes usually short, loosely spiralled, 2 to 4 micra in diameter; spirals 10 to 12 micra. Cell contents bright blue-green, distinctly granular. This species being highly variable will need more materials for further study.

SPIRULINA MAJOR Kutzing. Plate 3, fig. 13.

Spirulina major KÜTZING, Phyc. Gen. (1843) 183; TILDEN (1910) 83, Plate 4, fig. 46; SMITH (1950) 573–574, fig. 485a; GHOSE, Jour. Bur. Res. Soc. (3) 15 (1925) 246; RAO, Proc. Ind. Sci. (3) 8 (1938) 164.

Trichomes bright blue-green, twisted into a somewhat loose, regular spiral, 1.5 to 1.7 micra in diameter.

3. Genus OSCILLATORIA Vaucher, 1803

OSCILLATORIA AMPHIBIA C. Agardh. Plate 3, fig. 14.

Oscillatoria amphibia C. AGARDH, Aufzahlung, etc., Flora. 10 (1827) 632; WOLLE, (1887) 334, Plate 105, fig. 3; GOMONT, Monogr. Oscill.

(1893) 241–242; Plate 7, figs. 4–5; TILDEN, Minn. Alg. (1910) 73–74; Plate 4, figs. 19–20; WANG, Contr. Biol. Lab. Sci. Soc. China **8** (1933) fig. 17b; PRESCOTT, Cranbr. Inst. Sci. Bull. **31** (1951) 345, Plate 109, fig. 16.

Trichomes straight or curved, not tapering towards the apex. Apical cell rounded, calyptra none. Cells 1.8 to 4 micra in diameter, 2 to 4 times their diameter in length. Transverse walls marked with a single granule on either side throughout the length of the trichomes. Cell contents pale blue-green.

OSCILLATORIA TENIUS C. Agardh. **Plate 3, fig. 15.**

Oscillatoria tenuis C. AGARDH, Alg. Decad. **2** (1813) 26; GOMONT, Monogr. Oscill. (1893) 240, Plate 7, figs. 2–3; TILDEN, Rep. Surv. Bot. Ser. **8** (1910) 142, Plate 4, figs. 17–18. PRESCOTT, Cranbr. Inst. Sci. **31** (1951) 491, Plate 110, figs. 8, 9, and 14; TIFFANY and BRITTON, Algæ Ill. (1952) 346, Plate 93, fig. 1074; VELASQUEZ, Nat. App. Sci. Bull. (4) **10** (1950) 314–315; SORIANO and G. VELASQUEZ, Nat. App. Sci. Bull. (1) **12** (1952) 28, Plate 1, fig. 7.

Trichomes distinctly blue-green, straight or slightly flexuous especially at the anterior end which does not taper. Cells from 5 to 7 micra broad, shorter than wide, almost quadrate, with coarsely granulated protoplasm usually at the cross walls.

4. Genus PHORMIDIUM Kutzing, 1843

PHORMIDIUM MENNESOTENSE (Tilden) Drouet. **Plate 3, fig. 16.**

Phormidium minnesotense (Tilden) DROUET, Field Mus. Bot. ser. 20 (1942) 125–141; PRESCOTT, Cranbr. Inst. Sci. Bull. **31** (1951) 495; TIFFANY and BRITTON, Algæ Ill. (1952) 350, Plate 95, fig. 1099; G. VELASQUEZ, Nat. App. Sci. Bull. (3 & 4) **11** (1951) 216; SORIANO and G. VELASQUEZ, Nat. App. Sci. Bull. (1) **12** (1952) 36, Plate 2, fig. 4.

Filaments straight, individual sheaths not so distinct. Cells short-cylindric, from 2 to 3 micra in diameter, 3 to 5 micra long, constricted at the cross walls. Apical cells broadly rounded, noncapitate. Protoplasmic content homogenous, pale blue-green.

5. Genus LYNGBYA Agardh, 1824

LYNBYA MENEGHINIANA (Kutzing) Gomont.

Lyngbya meneghiniana (Kützing) GOMONT, Monogr. Oscill. (1893) 145; GOMONT, Monogr. Oscill. (1893) 145; TILDEN, Univ. Minn. Press, Minn. **1** (1910) 219; NIELSEN, Quart. Jour. Flor. Acad. Sci. (12) **18** (1955) 96.

Trichomes straight, enclosed by a hyaline sheath extending beyond the apical cell. Diameter of cells from 6.5 to 7 micra, a little less longer than wide. Apical cell more or less rounded.

Tychoplanktonic.

6. Genus ANABÆNA Bory, 1822

ANABAENA VARIABILIS Kutzing. **Plate 3, fig. 17.**

Anabæna variabilis KÜTZING, Phyc. Gen. (1843) 210; WOLLE (1887) 287–288, Plate 198, figs. 29–32; TILDEN, Univ. Minn. Press, Minn. (1910) 187, Plate 9, fig. 9; CHOSE, Jour. Burma Res. Soc. (3) **17** (1927) 241; PRESCOTT, Cranbr. Inst. Sci. Bull. **31** (1951) 519, Plate 118, figs. 9–10.

Trichomes flexuous, slightly constricted at joints, blue-green. Cells barrel-shaped, 4 to 5 micra in diameter, spherical or oval; gonidia 7 to 8 micra in diameter, 9 to 15 micra in length, more or less oval, in catenate series remote from the heterocysts. Cell contents slightly granular.

7. Genus ANABÆNA (Wolosz) Miller, 1923

ANABAENOPSIS CIRCULARIS (G. West) Miller emend. **Plate 3, figs. 18, 18a.**

Anabænopsis circularis (G. West) MILLER emend. (1923); TAYLOR, Jour. Bot. (6) **19** (1932) 456, Plate 39, figs. 5–10; SMITH (1950) 583–584; PRESCOTT, Cranbr. Inst. Sci. Bull. **31** (1951) 520.

Trichomes short, curved into a complete circle or coiled into short spirals usually of 1 to 2 turns. Cells somewhat cylindrical or slightly barrel-shaped, blue-green, slightly granular, 4.7 to 6 micra in diameter. Heterocyst at both ends of trichomes, more or less spherical, granulated, pale yellowish green.

8. Genus CALOTHRIX C. Agardh, 1824

CALOTHRIX PARIETINA (Naegeli) Thuret.

Calothrix parietina THURET in Fan, Extr. Rev. Alg. **31** (1956) 159–168, fig. 1.

Trichomes tapering from base to apex terminating abruptly. Basal portion of the sheath thickened. Vegetative cells in lower portion of the trichome a little longer than those toward the apices. Apical cell somewhat rounded. Cells deeply blue-green. Basal heterocysts present.

II. CHLOROPHYCEÆ

Plants characterized by grass-green chloroplastids; unicellular, colonial or filamentous; reproduction sexual or asexual.

Key to the genera

1. Plants not filamentous 2
1. Plants filamentous 3
    2. Cells solitary .... 1. *Tetrædron*
    2. Cells colonial .... 2. *Planktosphæria*

3. Filaments unbranched .... 3. *Oedogonium*
3. Filaments freely branched .... 4. *Cladophora*

1. Genus TETRÆDRON Kutzing, 1845

TETRAEDRON MUTICUM (A. Braun) Hansgrig. **Plate 3, fig. 19.**

Tetrædron muticum (A. Braun) HANSGRIG (1888a) 131; PRESCOTT, Cranbr. Inst. Sci. Bull. 31 (1951) 260, Plate 60, figs. 16–17; SMITH (1950) 269.

Cells bright green, flat, triangular, 6 to 9 micra in diameter, the angles without spines of furcations, sides of cells smooth or slightly concave.

TETRAEDON MINIMUM (A. Braun) Hansgrig. **Plate 3, fig. 20.**

Tetrædron minimum (A. Braun) HANSGRIG (1888a) 131; PRESCOTT, Cranbr. Inst. Sci. Bull. 31 (1951) 267, Plate 60, figs. 12–15; SMITH (1950) 269.

Cells bright green, flat, tetragonal, 6 to 10 micra in diameter; the angles without spines or furcations, somewhat rounded; the lobes sometimes cruciately arranged; margins of cells concave.

2. Genus PLANKTOSPHÆRIA G. M. Smith, 1918

PLANKTOSPHAERIA sp. **Plate 3, fig. 21.**

Planktosphæria sp. PRESCOTT, Cranbr. Inst. Sci. Bull. 31 (1951) 239; SMITH (1950) 255.

Colony free-floating. Cells distinctly green, spherical, enclosed in a homogenous envelope; chloroplasts several. Cell contents distinctly granular.

3. Genus OEDOGONIUM Link, 1820

OEDOGONIUM sp.

Oedogonium sp. SMITH (1950) 207; PRESCOTT, Cranbr. nst. Sci. Bull. 31 (1951) 156; TIFFANY and BRITTON, Algæ Ill. (1952) 57.

Filaments unbranched, cells cylindrical with straight walls transversely striated at distal ends. Basal cell forming a holdfast. Chloroplasts encircling the protoplast.

4. Genus CLADOPHORA Kutzing, 1843

CLADOPHORA sp.

Cladophora sp. SMITH (1950) 214; PRESCOTT, Cranbr. Inst. Sci. Bull. 31 (1951) 135–136; TIFFANY and BRITTON, Algæ Ill. (1952) 45.

Filaments freely branched laterally. Cells cylindrical, walls thick, branches smaller than main axis, tapering slightly towards the apices. Chloroplast a parietal network or fragmented.

Tychoplanktonic.

III. BACILLARIOPHYCEÆ

Plants characterized by golden brown pigments; wall of duplex structure, unicellular, colonial or filamentous; asexual reproduction by vegetative cell division and fragmentation or by aplanospores or special modifications of these. Sexual reproduction also present.

Key to the Genera

1. Valves symmetric 2
1. Valves asymmetric 4
   2. Valves greatly elongated and narrow .... 1. *Fragilaria*
   2. Valves moderately elongated 3
3. Valves gradually tapering towards more or less pointed ends. 2. *Navicula*
3. Valves with rostrate ends .... 3. *Mastogloia*
   4. Cells free-floating .... 4. *Cymbella*
   4. Cells epiphytic .... 5. *Epithemia*

1. Genus FRAGILARIA (Lynbye, 1819) Rabenhorst, 1864

FRAGILARIA sp.

Fragilaria sp. SMITH (1950) 479-480. TIFFANY and BRITTON, Algæ Ill. (1952) 231.

Cells solitary or in flat colonies, free-floating many times longer than broad, rectangular in girdle view. Valves bilaterally symmetric, bluntly rounded at the poles.

2. Genus NAVICULA Bory, 1822; emend Cleve, 1894

NAVICULA sp.

Navicula sp. SMITH (1950) 488–489; TIFFANY and BRITTON, Algæ Ill. (1952) 250.

Cells solitary and free-floating, rectangular in girdle view, valves lanceolate, gradually tapering to more or less pointed ends.

3. Genus MASTOGLOIA Thwaites, 1856

MASTOGLOIA sp.

Mastogloia sp. TIFFANY and BRITTON, Algæ Ill. (1952) 249; SMITH (1950) 497.

Cells solitary and free-floating, rectangular in girdle view, valves lanceolate, with rostrate ends.

4. Genus CYMBELLA C. A. Agardh, 1830

CYMBELLA sp.

Cymbella sp. SMITH (1950) 500–501; TIFFANY and BRITTON, Algæ Ill. (1952) 275.

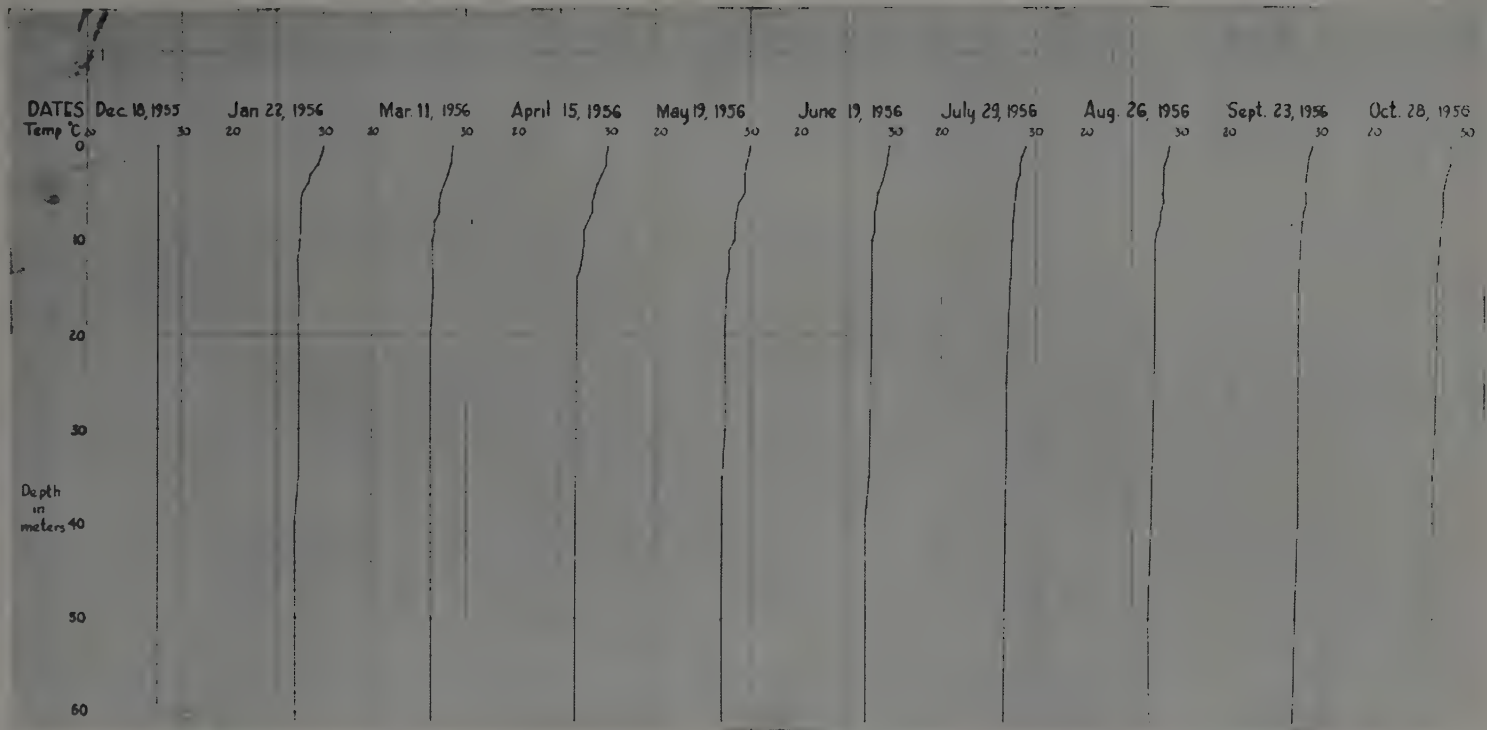


FIG. 4. *Vertical temperature gradients at Station IV from December 18, 1955 to October 28, 1956. Tadlak Lake, Los Baños, Laguna. Temperature plotted in degrees centigrade, depth in meters.*

Cells solitary and free-floating, more or less rectangular in girdle view, longitudinally asymmetrical in valve view with an almost lunate outline, dorsally convex, ventrally nearly straight and slightly concave at the middle.

5. Genus EPITHEMIA Brebisson, 1838

EPITHEMIA sp.

Epithemia sp. SMITH (1950) 502; TIFFANY and BRITTON, Algæ Ill. (1952) 280.

Cells solitary, epiphytic on Cladophora, attached at girdle, rectangular in girdle view. Valves slightly curved, dorsally convex, ventrally slightly concave, broadly rounded ends. Axial field next to concave side of valve with a V-shaped median extension towards the dorsal side.

Tychoplanktonic.

The thermal variations from December 18, 1955 to October 28, 1956 are shown in Table 5 and Fig. 4. Table 6 shows the monthly counts of the more common members of the phyto-

TABLE 5.—*Tadlak Lake vertical temperature series—Deg. C. December 18, 1955 to October 28, 1956.*

STATION IV

Depth in Meters	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28
0	27.50	30.00	28.60	30.00	30.00	29.50	29.00	29.00	29.00	28.40
1		29.70	28.40	29.80	29.60	29.30	28.69	28.80	28.69	28.40
2		29.30	28.40	29.70	29.49	29.10	28.38	28.48	28.48	28.40
3	27.50	28.69	28.00	29.19	29.40	28.99	28.28	28.39	28.48	27.09
4		28.28	27.78	28.89	29.40	28.79	27.98	28.29	28.29	27.80
5		27.68	27.27	28.49	29.30	28.39	27.98	28.29	28.30	27.79
6		27.60	27.28	28.20	28.89	28.19	27.88	28.00	27.99	27.79
7		27.60	27.28	28.20	28.48	27.99	27.78	27.99	27.99	27.50
8	27.50	27.58	26.78	27.69	28.29	27.99	27.78	27.99	27.99	27.49
9		27.58	26.78	27.48	28.30	27.99	27.58	27.78	27.79	27.49
10		27.48	26.48	27.49	28.19	27.89	27.58	27.58	27.79	27.28
11		27.39	26.48	27.28	27.99		27.48			
12		27.28	26.48	27.19	27.99		27.39			
13				27.00	27.99		27.39			
14				26.78	27.58		27.29			
15	27.49	27.28	26.48	26.78	27.58	27.78	27.19	27.49	27.49	26.99
16					27.49					
17					27.49					
18					27.39					
19					27.39					
20	27.49	27.28	26.28	26.78	27.30	27.68	27.00	27.49	27.49	26.99
25		27.29		26.78	27.30		26.89	27.28	27.49	26.79
30	27.49	27.30	26.28	26.78	27.19	27.49	26.80	27.19	27.49	26.80
35		27.30	26.28	26.78	26.99	27.29				26.50
40		26.99	24.28	26.58	26.99	26.99	26.79	26.99	27.30	26.49
45				26.58						
50		26.99	26.28	26.48	26.99	26.99	26.70	26.80	26.99	26.49
61	27.39	26.99	26.30	26.48	27.00	26.99	26.5	26.80	26.79	26.49

TABLE 6.—*Summary of the seasonal occurrence of phytoplankton in Tadlak Lake from December 18, 1955 to November 25, 1956.*

STATION I (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ											
Oscillatoria	5,333.33	55,600.00	1,529.00	4,000.00	12,133.20	5,066.40	9,040.00	6,000.00	1,066.40	2,132.80	1,333.33
Anacystis	8,444.00	26,800.00	400.00	1,000.00	4,666.40	3,866.40	1,200.00	3,800.00	1,066.40	2,932.80	2,133.33
Anabænopsis	888.80	000.00	000.00	200.00	000.00	000.00	400.00	000.00	000.00	266.40	000.00
Spirulina	000.00	000.00	000.00	500.00	2,266.40	1,466.40	000.00	133.20	000.00	000.00	000.00
CHLOROPHYCEÆ											
Planktosphæria	6,666.66	1,600.00	800.00	000.00	800.00	533.20	933.20	000.00	000.00	532.80	800.00
Tetrædron	000.00	800.00	80.00	000.00	1,325.20	133.20	000.00	000.00	266.40	000.00	800.00
DIATOMS	5,333.33	4,000.00	400.00	000.00	266.40	000.00	000.00	133.20	000.00	000.00	1,866.66
UNIDENTIFIED	000.00	000.00	000.00	000.00	266.40	000.00	000.00	000.00	000.00	000.00	266.66

STATION II (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ											
Oscillatoria	4,888.88	74,000.00	10,560.00	5,500.00	15,866.40	4,666.40	4,133.20	3,866.40	2,666.40	3,200.00	3,333.33
Anacystis	8,866.00	105,600.00	160.00	1,400.00	1,733.20	5,133.20	5,226.40	000.00	1,600.00	2,132.80	3,400.00
Anabænopsis	888.80	000.00	640.00	100.00	133.20	000.00	400.00	000.00	800.00	1,066.40	000.00
Spirulina	000.00	000.00	000.00	1,600.00	4,266.40	266.40	000.00	000.00	000.00	000.00	000.00
CHLOROPHYCEÆ											
Planktosphæria	4,444.00	4,400.00	1,760.00	300.00	533.20	666.40	000.00	133.20	266.40	000.00	800.00
Tetrædron	1,340.00	2,400.00	1,200.00	100.00	1,591.60	000.00	133.20	000.00	000.00	800.00	000.00
DIATOMS	8,444.00	8,400.00	1,440.00	200.00	133.40	000.00	133.20	000.00	1,066.40	1,600.00	2,400.00
UNIDENTIFIED	000.00	000.00	000.00	000.00	533.20	000.00	000.00	000.00	000.00	000.00	000.00

STATION III (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ											
Oscillatoria	4,000.00	92,000.00	10,560.00	9,400.00	6,800.00	4,400.00	9,200.00	3,066.40	3,732.80	2,932.80	2,400.00
Anacystis	10,221.32	48,400.00	2,640.00	2,200.00	7,600.00	3,653.20	6,666.40	800.00	2,933.28	2,132.80	2,933.33
Anabænopsis	888.80	000.00	640.00	100.00	000.00	000.00	1,733.20	000.00	532.80	266.40	800.00
Spirulina	000.00	400.00	000.00	100.00	2,400.00	266.40	000.00	000.00	000.00	000.00	000.00
CHLOROPHYCEÆ											
Planktosphæria	5,333.33	1,600.00	1,760.00	000.00	266.40	200.00	000.00	000.00	266.40	000.00	1,866.66
Tetrædron	000.00	6,000.00	1,200.00	000.00	266.40	266.40	133.20	266.40	266.40	000.00	000.00
DIATOMS	6,666.66	11,600.00	1,440.00	100.00	266.40	000.00	000.00	000.00	000.00	532.80	533.33
UNIDENTIFIED	000.00	000.00	000.00	000.00	800.00						

STATION IV (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ											
Oscillatoria	1,333.33	59,200.00	9,040.00	10,800.00	3,866.40	5,733.20	1,325.20	5,720.00	2,400.00	1,066.40	533.33
Anacystis	17,777.33	81,200.00	3,840.00	1,600.00	3,066.40	2,800.00	266.40	933.20	1,332.80	1,866.40	2,133.33
Anabænopsis	444.40	000.00	000.00	000.00	000.00	266.40	000.00	266.40	000.00	000.00	000.00
Spirulina	000.00	000.00	000.00	600.00	1,866.40	533.20	133.20	000.00	000.00	000.00	000.00
CHLOROPHYCEÆ											
Planktosphæria	6,666.66	000.00	2,160.00	400.00	666.40	800.00	000.00	266.40	000.00	800.00	1,866.66
Tetrædron	000.00	1,200.00	400.00	000.00	400.00	000.00	000.00	000.00	000.00	266.40	000.00
DIATOMS	4,888.00	2,000.00	1,680.00	000.00	000.00	533.20	000.00	000.00	000.00	000.00	800.00
UNIDENTIFIED	000.00	000.00	000.00	000.00	133.20	000.00	000.00	000.00	000.00	000.00	266.66

TABLE 7.—*Summary of the seasonal occurrence of phytoplankton in Tadlak Lake from December 18, 1955 to November 25, 1956.*

STATION IV (THIRTY METERS DEEP)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ											
Oscillatoria	1,495.33	6,728.97	5,981.33	5,981.33	3,971.92	6,728.97	7,476.62	6,728.97	5,214.95	3,734.58	5,214.95
Anacystis	4,485.92	3,734.58	4,485.92	3,734.58	3,734.58	5,981.33	5,214.95	2,990.66	2,990.66	2,242.96	3,734.58
Anabænopsis	000.00	000.00	640.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
Spirulina	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
CHLOROPHYCEÆ											
Planktosphæria	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
Tetrædron	747.66	1,495.33	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
DIATOMS	9,719.62	8,971.92	9,719.62	7,476.62	13,458.17	10,429.90	8,971.92	13,458.17	11,215.70	10,429.90	13,458.17
UNIDENTIFIED	000.00	000.00	747.66	000.00	000.00	000.00	000.00	000.00	747.66	000.00	1,495.33

STATION IV (SIXTY-ONE METERS DEEP)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ											
Oscillatoria	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
Anacystis	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
Anabænopsis	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
Spirulina	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
CHLOROPHYCEÆ											
Planktosphæria	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
Tetrædron	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
DIATOMS	747.66	747.66	747.66	1,495.33	000.00	000.00	747.66	747.66	747.66	747.66	747.66
UNIDENTIFIED	000.00	000.00						000.00	000.00	000.00	000.00

TABLE 8.—*Summary of the seasonal occurrence of phytoplankton in Tadlak Lake from December 18, 1955 to November 25, 1956.*

STATION I (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ	14,664.79	85,552.00	1,920.00	5,700.00	19,066.00	10,399.20	21,439.60	9,933.20	2,132.80	5,332.00	3,999.99
CHLOROPHYCEÆ	6,666.66	2,400.00	880.00	000.00	2,125.20	666.40	933.20	000.00	266.40	532.80	1,600.00
DIATOMS	5,333.33	4,000.00	400.00	000.00	266.40	000.00	000.00	133.20	000.00	000.00	1,866.66
UNIDENTIFIED PHYTOPLANKTON	000.00	400.00	000.00	000.00	266.40	000.00	000.00	000.00	000.00	000.00	266.66

STATION II (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ	14,221.27	179,600.00	4,880.00	7,900.00	21,999.20	10,066.00	9,759.60	3,866.40	5,065.60	6,399.20	5,733.33
CHLOROPHYCEÆ	5,784.00	6,800.00	80.00	400.00	2,124.80	666.40	133.20	133.20	266.40	800.00	800.00
DIATOMS	8,444.00	8,400.00	320.00	200.00	133.40	000.00	133.20	000.00	1,066.40	1,600.00	2,400.00
UNIDENTIFIED PHYTOPLANKTON	000.00	000.00	000.00	000.00	533.20	000.00	000.00	000.00	000.00	000.00	000.00

STATION III (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ	15,110.12	140,755.20	13,840.00	11,800.00	16,799.60	8,319.60	17,599.60	3,866.40	7,198.40	5,332.00	3,999.99
CHLOROPHYCEÆ	5,333.33	7,600.00	2,960.00	000.00	532.80	566.40	133.20	266.40	532.80	000.00	000.00
DIATOMS	6,666.66	11,600.00	1,440.00	100.00	266.40	000.00	000.00	000.00	800.00	800.00	800.00
UNIDENTIFIED PHYTOPLANKTON	000.00	000.00	000.00	000.00	800.00	000.00	000.00	000.00	000.00	532.80	266.66

STATION IV (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ	19,553.73	143,021.86	12,080.00	13,080.00	8,799.20	9,332.40	1,724.80	6,919.60	3,732.80		2,666.66
CHLOROPHYCEÆ	6,666.66	1,200.00	2,560.00	400.00	1,066.40	800.00	000.00	266.40	000.00		1,866.66
DIATOMS	4,888.00	2,000.00	1,680.00	000.00	000.00	533.20	000.00	000.00	000.00		800.00
UNIDENTIFIED PHYTOPLANKTON	000.00	000.00	000.00	000.00	133.20	000.00	000.00	000.00	000.00		266.66

STATION IV (THIRTY METERS DEEP)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ	5,981.25	10,463.55	10,467.25	9,715.91	12,706.51	12,710.30	12,691.57	9,719.63	8,205.61	5,977.54	8,949.53
CHLOROPHYCEÆ	747.66	1,495.33	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
DIATOM S	9,719.62	8,971.92	9,719.62	7,476.62	13,458.17	10,429.90	8,971.92	13,458.17	1,121.49	10,429.90	13,458.17
UNIDENTIFIED PHYTOPLANKTON	000.00	2,990.66	747.66	000.00	000.00	000.00	000.00	000.00	747.66	000.00	1,495.33

STATION IV (SIXTY-ONE METER DEEP)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
MYXOPHYCEÆ	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	8,205.61	000.00	000.00
CHLOROPHYCEÆ	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
DIATOMS	747.66	747.66	747.66	1,495.33	747.66	000.00	747.66	1,495.33	1,121.49	747.66	747.66
UNIDENTIFIED PHYTOPLANKTON	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	747.66	000.00	000.00

TABLE 9.—*Summary of the seasonal occurrence of phytoplankton and zooplankton in Tadlak Lake from December 18, 1955 to November 25, 1956.*

STATION I (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
PHYTOPLANKTON	26,664.78	92,352.00	3,200.00	5,700.00	21,624.00	11,065.60	22,372.80	10,066.40	2,399.20	5,864.80	7,733.31
ZOOPLANKTON	888.80	000.00	80.00	000.00	000.00	266.40	4,400.00	1,066.40	000.00	000.00	533.33
PLANKTON	27,553.58	92,352.00	3,280.00	5,700.00	21,624.00	11,332.00	26,772.80	11,132.80	2,399.20	5,864.80	8,266.64

STATION II (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
PHYTOPLANKTON	28,449.27	194,800.00	5,280.00	8,500.00	24,790.60	10,732.40	10,026.00	3,999.60	6,398.40	8,799.20	8,933.33
ZOOPLANKTON	444.40	4,800.00	80.00	800.00	1,600.00	666.40	15,466.40	2,533.20	532.80	532.80	533.33
PLANKTON	28,893.67	199,600.00	5,360.00	9,300.00	26,390.60	11,398.80	25,492.40	6,532.80	6,931.20	9,332.00	9,466.66

STATION III (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
PHYTOPLANKTON	27,110.11	159,955.20	18,240.00	11,900.00	18,398.80	8,885.00	17,732.80	4,132.80	8,531.20	6,664.80	5,333.32
ZOOPLANKTON	444.40	2,000.00	1,280.00	1,400.00	1,325.20	3,333.20	3,866.40	1,866.40	1,332.80	800.00	1,333.33
PLANKTON	27,554.51	161,955.20	19,520.00	13,300.00	19,724.00	12,218.20	21,599.20	5,999.20	9,864.00	7,464.80	6,666.65

STATION IV (SURFACE)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
PHYTOPLANKTON	31,108.39	146,221.86	16,320.00	13,480.00	9,998.80	10,665.60	1,724.80	7,186.00	3,732.80	3,998.40	4,533.32
ZOOPLANKTON	8,444.40	000.00	000.00	200.00	000.00	000.00	3,333.20	1,325.20	266.40	000.00	266.66
PLANKTON	39,552.79	146.221.86	16,320.00	13,680.00	9,998.80	10,665.60	5,058.00	8,511.20	3,999.20	3,998.40	4,799.98

STATION IV (THIRTY METERS DEEP)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
PHYTOPLANKTON	16,448.53	23,921.46	20,934.53	17,192.53	26,164.68	23,140.20	21,663.49	23,177.80	10,074.76	16,407.44	23,903.03
ZOOPLANKTON	8,224.29	2,990.66	2,242.96	2,990.66	1,475.33	2,990.66	1,495.33	2,242.96	2,990.66	2,242.96	3,734.58
PLANKTON	24,672.82	26,912.12	23,177.49	20,183.19	27,640.01	26,130.86	23,158.82	25,420.76	13,065.42	18,650.40	27,637.61

STATION IV (SIXTY-ONE METER DEEP)

	Dec. 18	Jan. 22	Mar. 11	April 15	May 19	June 19	July 29	Aug. 26	Sept. 23	Oct. 28	Nov. 25
PHYTOPLANKTON	747.66	747.66	747.66	1,495.33	747.66	000.00	747.66	1,495.33	747.66	747.66	747.66
ZOOPLANKTON	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
PLANKTON	747.66	747.66	747.66	1,495.33	747.66	000.00	747.66	1,495.33	747.66	747.66	747.66

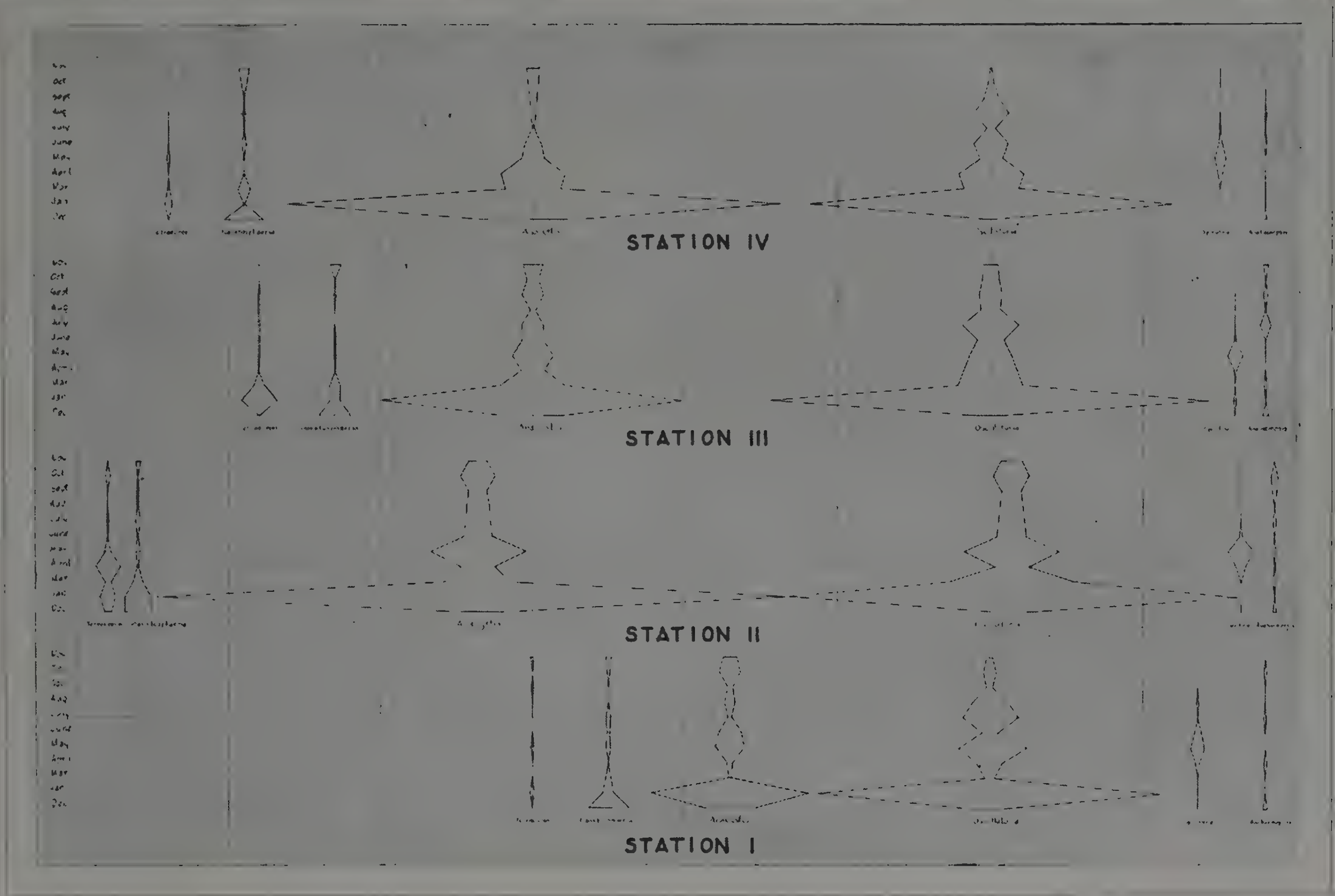


FIG. 5. *Graphic representation of seasonal variations of the different genera of phytoplankton.*

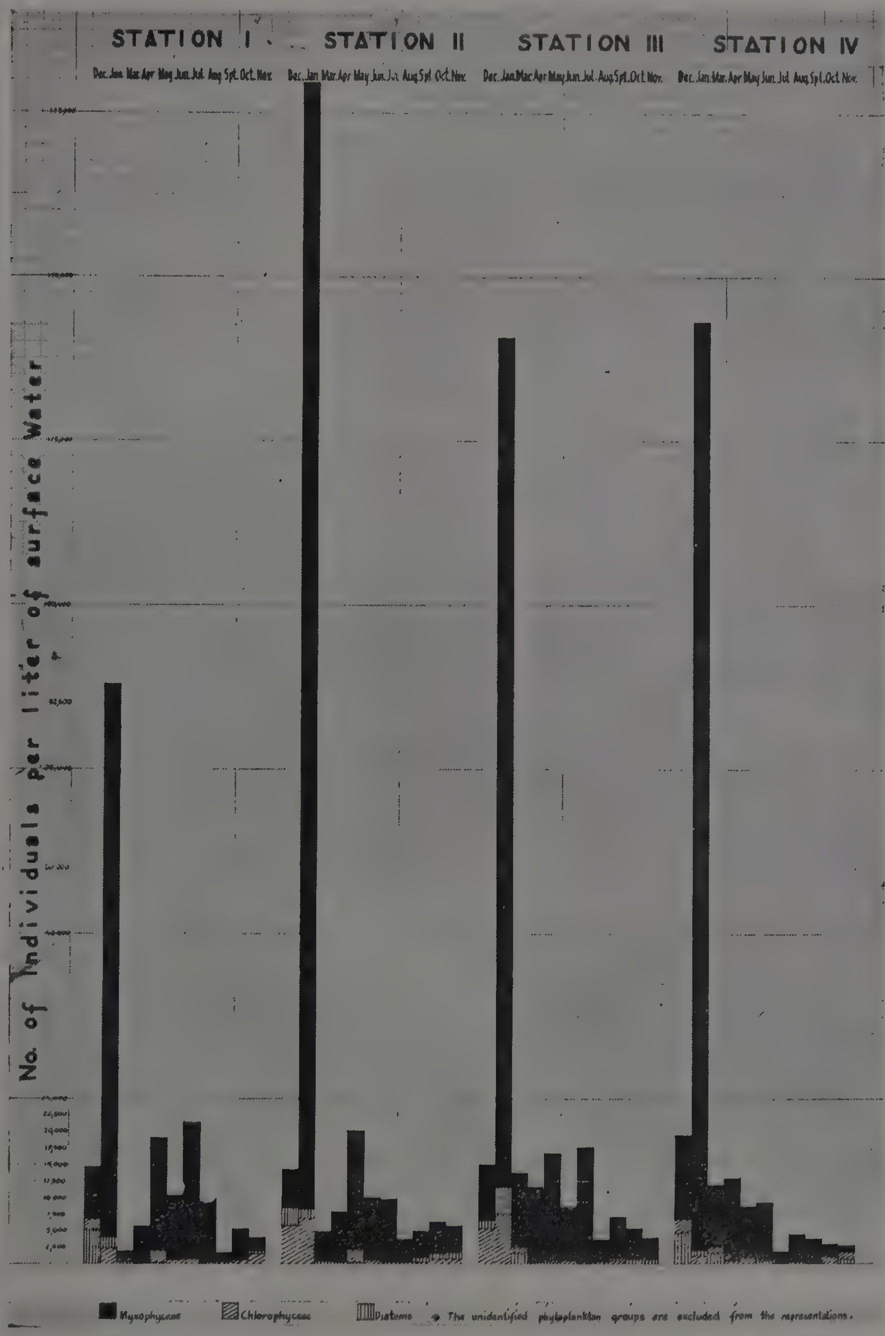
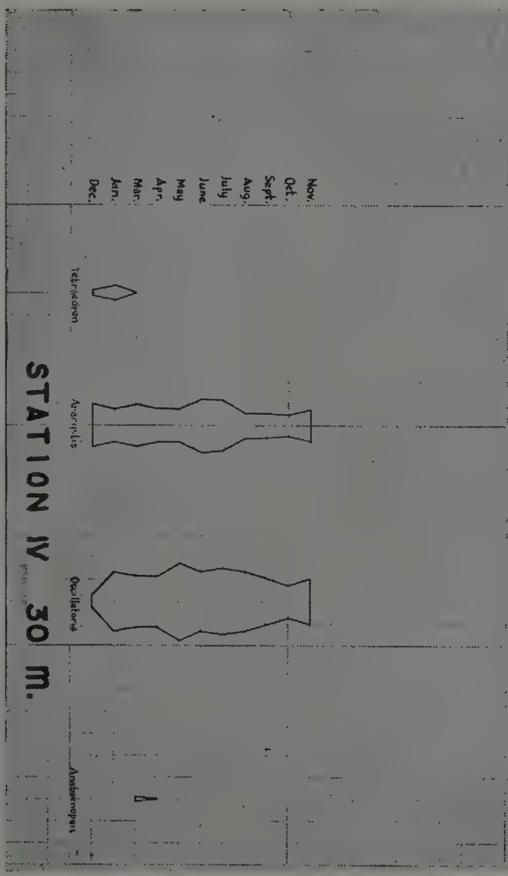


FIG. 6. *Graphic representations of the quantitative seasonal variations of phytoplankton groups at the surface.*



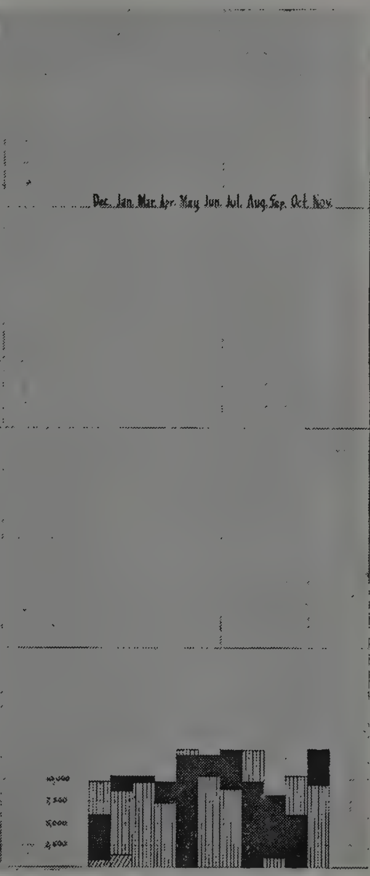


FIG. 7. *Quantitative seasonal variation of phytoplankton at a depth of thirty meters.*

FIG. 8. *Seasonal variations of phytoplankton groups at a depth of thirty meters.*

plankton groups in units per liter of lake water. The diatoms were counted only as one group; the tychoplankters excluded. Figs. 5, 7, and 8 show the seasonal variations of these different genera of phytoplankton. A summary of the total counts of the phytoplankton groups present during the periods of collection are represented in Table 8 and Fig. 6. The comparative amounts of total phytoplankton and zooplankton as well as total plankton are shown in Table 9.

Phytoplankton on the surface waters reaches its highest peak in January with a maximum of 194,800.00 per liter. The amount was sufficiently high to impart a dark olive greenish color to the water. This pulse terminated in March followed by a smaller increase in May. In June the phytoplankton had a slight decrease, increasing slightly in July reaching up to the May level. Phytoplankton was at its lowest during the months of September, October, and November.

The January peak was preceded by rains in December and a short dry spell ushering the dry season. A slight increase in dissolved oxygen was also noted. The pH of the water remained constant but showed a slight decrease in March when the phytoplankton pulse terminated. Dissolved oxygen in the water also showed a slight decrease during the same period. Limit of visibility in the water was at its lowest in January when phytoplankton was at its maximum.

The second phytoplankton peak occurred in May with the onset of the rainy season. Although much smaller compared to the January pulse, it was also accompanied by a slight increase in temperature of the water and a notable increase in the amount of dissolved oxygen. Abundance of algæ in the shallower portions of the lake such as *Cladophora*, *Oedogonium*, and *Lyngbya* together with *Calothrix* also occurred during this period. These algæ persisted until September after which they were found to be scarce. Limit of visibility in May was higher than in March or April and continued increasing until it reached a maximum of 9.75 feet in July.

During the later part of the rainy season phytoplankton was at its minimum. Temperature of the water was also at a minimum together with dissolved oxygen. H-ion concentration of the water remained almost constant at 8.0 and 8.2 during the period of phytoplankton low. It is interesting to note that phytoplankton maxima did not coincide with zooplankton maxima

but was usually followed by it. With the decline of the January pulse, a slight zooplankton increase was observed. During the months of phytoplankton minima, zooplankton was more abundant.

The usual concentration of surface phytoplankton was found not in the open water but in the more protected portions, particularly where there was little wind and wave action. Higher quantities of phytoplankton per liter of surface water were frequently found in the stations in the direction of the wind. During the months of December, January, March, April, June, July, August, October and November, with the winds coming from the northeast or northwest direction, Station II was found to have a greater concentration of phytoplankton than the rest of the stations. In September, with the wind coming from the southwest, more phytoplankton were observed in Station III.

Other physical disturbances also affect phytoplankton distribution. Station I which was continually subjected to such physical disturbances consistently showed a lower concentration of phytoplankton than other stations.

At thirty meters a paucity of phytoplankton species particularly the Chlorophycean group was observed (Table 7). Light penetration is much reduced for photosynthetic activity at this level for the phytoplankters. Diatoms were a little more than at the surface. During the months when the limit of visibility readings were highest, a slight increase in the Myxophycean species were noted.

At sixty-one meters deep, available light obviously is at a minimum, no phytoplankton were found except for a few diatoms. The pH readings at the bottom were a little higher than at the surface and at the middle. Temperature was also found to be lower.

Representatives of the Class Myxophyceæ predominated throughout the entire year. Of these, *Anacystis* together with *Oscillatoria* constituted a large majority at the surface and at 30 meters deep. In the January phytoplankton pulse, *Anacystis* reached its peak of 105,600 units per liter at Station II. A second peak occurred in May although this was not as distinctive as that in January. In July, *Anacystis* was at its minimum. At 30 meters deep variations were only very slight.

Oscillatoria followed almost the same pattern as *Anacystis* in its occurrence although in lesser quantities. A maximum of 74,000 units per liter was observed in January at Station II.

Anabænopsis occurred mostly on the surface water particularly at the sides. They were present only in the open waters in December, June, July, and August in quantities not reaching 1,000 units per liter. A maximum of 1,733.00 units per liter was reached in July at Station II.

Spirulina was found only on the surface from January through August with a maximum amount of 4,266.4 units per liter at Station II in May.

Although representing the minority, Chlorophycean species were present in all the phytoplankton collection throughout the year. Only one genus of the Chlorophyceæ was found at 30 meters deep. It was found to be totally absent at 61 meters.

Planktosphæria appeared in all the phytoplankton collections; the maximum abundance was 6,666.66 units per liter at Station I and IV in December.

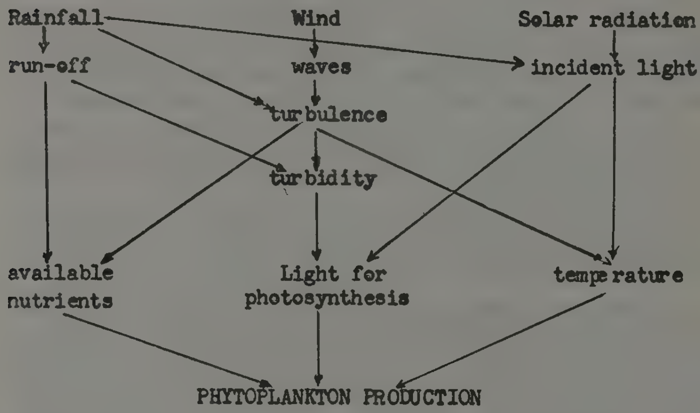
Tetrædron was present in all the collections at the surface and at 30 meters deep in December and January. Its maximum was 6,000 units per liter in January at Station III.

Diatoms were found in all the collections at the surface, at 30 meters and at 61 meters deep. At 30 meters deep the diatoms constituted the bulk of the phytoplankton populations. At the surface they were found to be more abundant at the periphery of the lake than in the open waters. Diatoms reached their peak of abundance in January at Station III reaching 11,600 units per liter. At 30 meters diatom composition remained more or less uniform except for a little decline in August. Only *Navicula* were found at 61 meters deep in all the phytoplankton collections except for the months of May and June. Diatoms at this depth occurred at its maximum at only 1,495.33 parts per liter of water.

That the phytoplankton distribution in Tadlak Lake undergoes variations during the different seasons of the year is evident from the foregoing data. The phytoplankton, however, does not follow a definite pattern of rise and fall as compared to temperate countries where conditions from season to season are distinct. Based on the results of the investigations, an attempt is made to evaluate the climatic as well as other physicochemical factors in the water affecting phytoplankton distribution.

The quality and quantity of phytoplankton are undoubtedly controlled by a combination of numerous interrelated factors.

Seemingly important components in this combination of factors affecting seasonal distribution of phytoplankton in Tadlak Lake are rainfall, wind, and solar radiation. Individually, or in combination, these three climatic factors affect phytoplankton production directly or indirectly in a complex manner. The following diagram patterned after that of Welch(44) attempts to show the relationships of their effect:



Increase solar radiation has been commonly associated with increase in phytoplankton production (Chandler, 1944; Wallen, 1949; Blum, 1956; Jolly, 1952). Observations in Tadlak Lake show a sharp increase in phytoplankton in January at the onset of the dry season. A lesser increase occurred in May and a still smaller one in July. Collections during these months were made during periods preceded by several days of clear weather. It would seem, therefore, from the data gathered that light is responsible in a large part in increases of surface phytoplankton in Tadlak Lake.

According to Welch (1952) the amount of effective light penetration into the water will determine the depth distribution of phytoplankton. Its total absence or inefficiency in quality or quantity eliminates phytoplankton particularly in deeper waters. The decrease in quality and quantity of phytoplankton in Tadlak Lake at 30 meters deep and its total absence at 61 meters deep except for a few diatoms may be due primarily to light deficiencies at these depths.

Effective light penetration into the water is largely affected by lake turbidities to a point which curtails or completely prevents phytoplankton growth. In the March collections following the January phytoplankton pulse, counts were at a minimum at the surface. This decrease may have been partly due to increased turbidity of the water (and consequently, decreased light penetration) caused by the phytoplankton themselves in the preceding month. Myxophyceæ at thirty meters deep during periods of decreased limit of visibility was slightly lower than in those months when limit of visibility readings were highest.

In Tadlak Lake the temperature of the water is controlled to a large extent by wind and sunlight. With increase in effective sunlight, temperature of the water increases. On the other hand, strong winds produce a cooling effect. During months when the wind was strong the lake surface temperature was slightly lower. Thermal stratification does not exist in the lake in spite of its considerable depth. The warming of its deeper waters may be attributed to some possible form of circulation caused by wind, higher salt content at lower level and the existence of warm underground springs. Since the lake is located in a volcanic area, the latter possibility can not be eliminated. The absence of sharp differences in atmospheric temperature with the seasons may further explain the lack of thermal stratification.

The amount of dissolved gases in the water such as O_2 and CO_2 in solution will limit the quantity of phytoplankton a body of water can support. A good supply of CO_2 and O_2 together with other favorable conditions may influence the development of water "blooms" which are usually followed by a series of biological conditions. Chemical analysis of the water for dissolved gases show that the free carbon dioxide is either absent or present only in traces. The paucity of phytoplankton species present in the lake may be partly due to this condition. Alkaline determinations indicate that the water contains carbon dioxide in a half-bound state as bicarbonates; also dissolved carbonates are present in large quantities. The almost constant high alkaline values of the water may be due to these dissolved bicarbonates and carbonates. The surrounding slopes and basin of a calcareous nature may have greatly contributed to these dissolved substances and the paucity of the phytoplankton species.

The presence of large amounts of carbonates, i.e., large amounts of salts, may cause an increase in temperature at lower depths as is the case of meromictic lakes.

The results of the investigation show that the increase in phytoplankton production seems to coincide with the increase in dissolved oxygen. This increase in dissolved oxygen, however, can not be wholly attributed to the phytoplankton but also to the algæ along the shores as well as to the vegetation touching the water along the shore, and in addition, the atmospheric oxygen. During the observations in May, a sharp increase in dissolved oxygen was noted at the time when attached algæ like *Cladophora* and *Oedogonium*, and *Lyngbya* covered a large portion of the shore. Occasional rains and a rise in water level were also noted at the time. Strong winds were likewise prevalent and therefore more water surface circulation.

Phytoplankton maxima did not coincide with the abundance of zooplankton. During the January increase of phytoplankton only a few zooplankton were observed. After the phytoplankton pulse, the zooplankton increased in number. The grazing effects of the zooplankton, the difference in the rate of reproduction and other influences may explain the phenomenon.

No direct effects of rainfall on the phytoplankton were observed in Tadlak Lake as no determinations of the actual amount of rainfall were made. It was noted that increase in water level occurred during the rainy season. This could be partly attributed to run-off water from the surrounding slopes. Increased amounts of dissolved nutrients may have been carried into the lake; with increase in nutrients there would consequently be an increase in phytoplankton production. The months during the rainy period showed slight increases only in phytoplankton production. Disturbances caused by rainfall and run-off water on the surface water may have curtailed a possible large increase or "bloom."

SUMMARY AND CONCLUSIONS

1. Morphometric studies show that the lake is more or less oval in outline with an area of around 270,000 square meters and a maximum depth of 65 meters with an abrupt slope. It has no visible inlets and outlets and is surrounded on all sides by slopes of marl.

2. Studies were made on the phytoplankton of Tadlak Lake to determine its seasonal distribution and to know the comparative effects of the factors affecting this distribution. The investigations were conducted for a one-year period starting December 18, 1955 to November 25, 1956.

3. Monthly observations were taken of the prevalent climatic and physico-chemical nature of the water at the time of collection. Qualitative and quantitative phytoplankton counts were made in all the observations.

4. Findings on the effects of prevalent climatic conditions on phytoplankton distribution are as follows: (*a*) sunlight available for photosynthetic processes apparently determine the distribution, particularly vertical distribution, to a large extent; (*b*) wind action during fairly strong constant wind affects phytoplankton directly by causing phytoplankton drifts and indirectly contributing to slight circulation at lower depths; (*c*) effects of rainfall seem to be indirect. Physico-chemical changes may occur thus affecting the quantity and quality of the phytoplankton in Tadlak Lake.

5. Analysis of the physico-chemical factors in the lake indicates that: (*a*) light penetration was highest during the warmer months of July and August than during the colder months of December and January; (*b*) changes in temperature with the seasons are only slight. The lake is nearly homothermous throughout the year. No thermal stratification was observed; (*c*) the lake is decidedly alkaline. H-ion readings were more or less constant at 8.0 to 8.4. Alkalinity determinations show that high amounts of dissolved carbonates and lesser quantities of bicarbonates are present. Alkalinity values at the bottom are somewhat slightly higher than in the upper waters; these may explain higher temperatures at the bottom. In this respect, Tadlak Lake may be considered meromictic.

6. Phytoplankton in Tadlak Lake is represented by 22 species of 17 genera, 8 of which are Myxophyceæ; 4, Chlorophyceæ; and 5, Bacillariophyceæ. *Anacystis* predominates the phytoplankton at the surface. At 30 meters deep, diatoms are more common than the other phytoplankton groups. Only a few diatoms were found at 61 meters deep. However, findings at this depth need further study.

7. Phytoplankton *maxima* do not coincide with that of the zooplankton but is usually followed by it.

8. Paucity of the phytoplankton species in the lake may be partly influenced by the small amount of dissolved free carbon dioxide. The alkalinity of the water may also be responsible for limiting phytoplankton production.

9. Peaks in phytoplankton production were found to coincide with increases in dissolved oxygen in the water.

10. As a whole, phytoplankton production in Tadlak Lake shows only slight variations in quality throughout the year. Quantitative variations although occurring at certain times are relatively small compared to that of temperate lakes where seasonal changes are well marked.

11. Based on the physico-chemical features and the biological findings, Tadlak Lake is considered an oligotrophic lake.

BIBLIOGRAPHY

1. AHLSTROM, E. H. The deep-water plankton of Lake Michigan, exclusive of the Crustaceæ. Trans. Amer. Micros. Soc. (3) **55** (1936) 286–299.
2. ALLEN, W. E. Method of field and laboratory procedure in phytoplankton research at the Scripps Institution of Oceanography of the Univ. of Calif. **21** (1940) 525–528. Pac. Sci. Congr. Proc. (1939) 3.
3. BEHRE, KARL. Die Susswasseralgen del Wallacea-Expedition. Archiv f. Hydrobiologic. Suppl. Bd. **33** (1956) 1–104, 10 plates.
4. BERNER, L. M. Limnology of the lower Missouri River. Ecol. (1) **32** (1951) 1–12.
5. CHANDLER, D. C. Limnological studies of the Western Lake Erie IV (relation of ecological and climatic factors to the phytoplankton of 1941). Trans. Amer. Micros. Soc. **63** (1944) 203–236.
6. CHAPMAN, V. J. An introduction to the study of algæ. The Macmillan Co., N.Y. (1941) 275.
7. CUNNINGHAM, B. T., et al. A survey of the western coastal dune lakes of the North Island, New Zealand. Aus. Jour. Mar. Freshwater Res. (1) **4** (1953) 343–886.
8. DROUET, F., and W. A. DAILY. The planktonic fresh-water species of Microcystis. Chicago Field Mus. Nat. Hist. (3) **75** (1939) 67–83.
9. DROUET, F., and W. A. DAILY. Revision of the coccoid Myxophyceæ. Butler Univ. Bot. Stud., Dept. Bot., Butler Univ. Indiana **12** (1956) 35–42.
10. EGGLETON, F. E. Limnology of a meriomictic, interglacial, plunge-basin lake. Trans. Amer. Micros. Soc. (3) **75** (1956) 334–378.
11. FERGUSON, WOOD, E. J. Consideration on productivity. Extrait Jour. Conseil International Pour l'Exploration de la Mer. (3) **21** (1956) 280–283.
12. FRITSCH, F. E. The structure and reproduction of the algæ. Univ. Press, Cambridge **2** (1945) 339pp.

13. GILBERT, J. Y. The errors of the Sedgewick-Rafter counting chamber on the enumeration of phytoplankton. Trans. Amer. Micros. Soc. (3) **61** (1942) 217–226.
14. GOMONT, M. Monographie des Oscillariées (1893) 260–275, Plates 7 and 8.
15. HUTCHINSON, G. E. and G. E. PICKFORD. Limnological observations on Mountain Lake, Virginia. Int. Rev. ges Hydrobiol. u. Hydrogr. **27** (1932) 252–264.
16. JOLLY, V. H. A preliminary study of the limnology of Lake Hayes. Aus. Jour. Mar. Fresh-water Res. (1) **3** (1952) 74–91.
17. KETCHUM, B. H. Plankton algæ and their biological significance. Manual of Phycology. Chron. Bot., Mas. **17** (1951) 335–344.
18. KISS, I. Bioclimatologic observations on the water-bloom of Eudorina elegans. Biol. Abstr. **24** (1950) 29110.
19. KOLKURITZ, R. Tropische algenbestande und ihre entwichlungsbedingungen. Biol. Abstr. (5) **8** (1932) 1934.
20. LACKEY, J. B., and E. R. HUPP. Plankton populations in Indiana's White River. Reprint Jour. Amer. Water Works Assoc. (8) **48** (1956) 1024–1036.
21. LITTLEFORT, R., et al. An experimental study of certain quantitative plankton methods. Biol. Abstr. **15** (1941) 1931.
22. LUCAS, C. F. The ecological effects of external metabolites. Biol. Abstr. **22** (1948) 10080.
23. MEGIA, T. G., and E. R. SEBASTIAN. Equipment and methods used in oceanographic investigations. Phil. Jour. Fish. (2) **2** (1953) 166–167.
24. PALMER, C. M., and C. M. TARZEWELL. Algæ of importance in water supplies. Reprint Public Works Mag. U.S.A. (1955).
25. PATERSON, M. A study of the seasonal distribution of plankton in White Rock Lake. Biol. Abstr. **17** (1943) 4275.
26. PRESCOTT, G. W. Algæ of the Western Great Lakes area. Cranbr. Inst. Sci. Bull. **21** (1951) vii–946.
27. RABANAL, H. R., and R. S. ESGUERRA, et al. The rate of algal production in Dagat-dagatan salt-water fishery experimental station fishponds. Phil. Fish. Handb. (1953) 142–152.
28. SHAW, W. Merrilosphæra africana at Manila. Philip. Jour. Sci. **22** (1923) 185–211.
29. SMITH, G. M. The phytoplankton of Muskoka Region, Ontario, Canada. Trans. Wisc. Acad. Sci. Arts & Lett. **20** (1922a) 323-364.
30. SMITH, G. M. The phytoplankton of some artificial ponds near Stockholm. Arkiv. For. Bot. (13) **17** (1922b) 1–8.
31. SMITH, G. M. Fresh-Water Algæ of the United States. McGraw-Hill Book Co., Inc., N. Y. (1950) 1–719.
32. SORIANO, J. D., and G. T. VELASQUEZ. Myxophyceæ of Manila and vicinity. Nat. App. Sci. Bull. (1) **12** (1952) 25–28, Plate 1, fig. 7.
33. TAYLOR, Wm. R. Notes on the genus Anabænopsis. Amer. Jour. Bot. (6) **19** (1932) 454–462, Plates 39–40.
34. TILDEN, J. Minnesota algæ. Univ. Minn. Press, Minn. **1** (1910) 1–319.
35. VELASQUEZ, G. T. On the viability of algæ obtained from the diges-

tive tract of the gizzard shad, Dorosoma cepedianum (Le Sueur). Amer. Midland Nat. **22** (1939) 376–412. Plates 1–2.

36. Velasquez, Filamentous Myxophyceæ of the Philippines II. Nat. App. Sci. Bull. (2) **8** (1941a) 189–200.
37. Velasquez, G. T. Filamentous Myxophyceæ of the Philippines. Ibid. (3) **8** (1941b) 203–210.
38. Velasquez, G. T. Studies on the Myxophyceæ of Puerto Galera and vicinity. Ibid. (4) **10** (1950) 309–328.
39. Velasquez, G. T. Additional records of Philippine Myxophyceæ. Ibid. (3 & 4) **11** (1951) 208–229.
40. Velasquez, G. T. Algal pollution from ponds at Puerto Galera, Oriental Mindoro, Philippines. Ibid. (3) **12** (1952) 239–258.
41. Villadolid, D. V., and D. K. Villaluz. A study on bañgus cultivation and its relation to algæ culture in the Philippines. Dept. Agri. Nat. Res. Bull. **30** (1950) 1–16.
42. Ward, H. B., and G. C. Whipple. Fresh-Water Biology. J. Wiley and Sons Inc., N. Y. (1945) 1–510.
43. Welch, P. S. A limnological study of a small sphagnum leatherleaf black spruce bog lake with special reference to its plankton. Trans. Amer. Micros. Soc. (3) **55** (1939) 300–312.
44. Welch, P. S. Limnological studies of the Western Lake Erie. Trans. Amer. Micros. Soc. **63** (1944) 203–235.
45. Welch, P. S. Limnological Methods. Blakiston Co., Phila. (1948) v, 381.
46. Woltereck, R. Die Seen und Inseln der "Wallacea" Zwischenregion und ihre endemische Tierwelt. Teil 1 und 2 (1941).
47. Yamazi, I. Plankton investigation of inlet waters along the coast of Japan, XI. The plankton of Kozima Bay in the Seto Naikai (inland sea). Publ. Mar. Biol. Lab. (3) **3** (1954a) 399–421.
48. Yamazi, I. Plankton investigation of inlet waters along the coast of Japan, XII. The plankton of Miyako Bay on the Eastern coast of Tokyo District. Ibid. (1954b) 423–441.

ILLUSTRATIONS

PLATE 1

FIG.. 1. Station I, a shallow exposed spot on the northeast side of the lake with a narrow shoreline.
2. A general view of the southeastern side of the lake where Station II is located.
3. Station III, a spot shaded by overhanging vegetation on the northeastern side just below a steep rocky hill.
4. The northeastern side of the lake where Station III is located.

PLATE 2

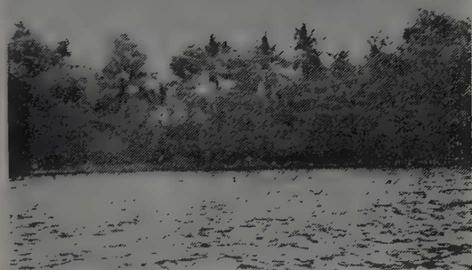
FIG. 5. View of the side of the lake with a narrow bank.
6. The northeastern side of the lake which has developed a narrow rocky shore.
7. The northwestern side showing a dense growth of vegetation overhanging the water.
8. The western side of the lake bordered by a small wooded hill.

PLATE 3

FIG. 9. *Anacystis cyanea* Drouet and Daily.
10. *Anacystis thermalis* fo. *thermalis* Drouet and Daily.
11. *Anacystis dimidiata* Drouet and Daily.
12. *Spirulina princeps* (West and West) G. S. West.
13. *Spirulina major* Kützing.
14. *Oscillatoria amphibia* C. A. Agardh.
15. *Oscillatoria tenuis* C. A. Agardh.
16. *Phormidium minnesotense* (Tilden) Drouet.
17. *Anabæna variabilis* Kützing.
18. *Anabænopsis circularis* (G. S. West) Miller. An old filament about to break at the middle of the two heterocysts.
18a. *A. circularis* (G. S. West) Miller. A young filament.
19. *Tetrædron muticum* (A. Braun) Hansgrig.
20. *Tetrædron minimum* (A. Graun) Hansgrig.
21. *Planktosphæria* sp.

PLATE 1.

5



6

7

8

PLATE 2.

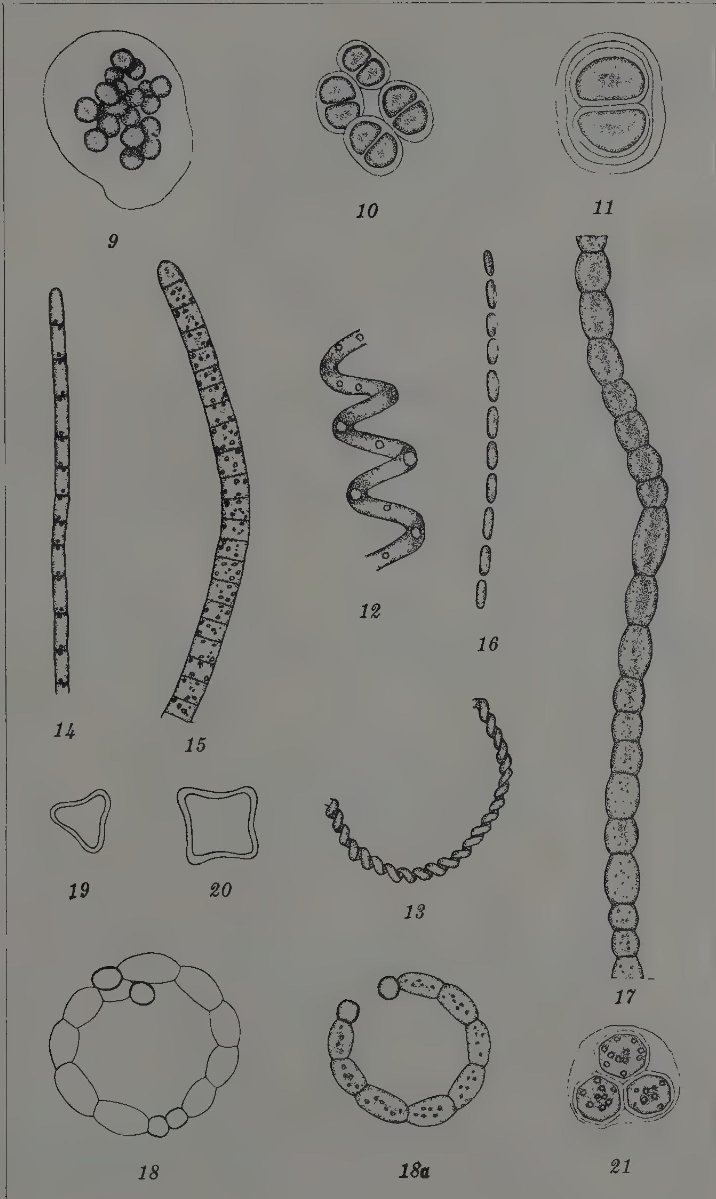


PLATE 3.

NEW FORMS OF HOLOTHURIOIDEA FROM THE VICINITY OF SOUTHERN CALIFORNIA AND MEXICO IN THE COLLECTION OF THE ALLAN HANCOCK FOUNDATION, UNIVERSITY OF SOUTHERN CALIFORNIA IN LOS ANGELES, CALIFORNIA*

By Jose S. Domantay

Bureau of Fisheries, Diliman, Quezon City, Philippines

SUMMARY

Fourteen new forms are listed in this paper representing 3 species of the genus *Bathyplotes* of the family Synallactidæ of the order Aspidochirota; 1 species of the genus *Athyonidium*, 1 species of *Phyllophorus*, of the family Phyllophoridæ and 2 species of *Cucumaria*, 2 species of *Leptopentacta*, 4 species of *Thyone*, family Cucumariidæ of the order Dendrochirota; and 1 species of the genus *Gephyrothuria*, family Gephyrothuriidæ, order Molpadia.

All the new species of holothurids were reported without description in paper entitled "A brief summary of the Pacific and Atlantic Holothurioidea of the Allan Hancock Foundation Collection." This paper is published in justification of 'nomina nuda', mentioned above.

Order ASPIDOCHIROTA Grube, 1840

Family SYNALLACTIDÆ Ludwig, 1894

Genus BATHYPLOTES Ostergren, 1896

1. *Bathyplotes hancocki* Domantay
2. *B. macullochæ* Domantay
3. *B. veleronis* Domantay

Order DENDROCHIROTA Grube, 1840

Family PHYLLOPHORIIDÆ Grube, 1840

Genus ATHYONIDIUM Deichmann, 1941

4. *Athyonidium deichmannæ* Domantay

Genus PHYLLOPHORUS Grube, 1840

5. *Phyllophorus panningi* Domantay

* Sequence to the writer's previous report published in the Philip. Jour. Sci. **82** (1953) 133–140.

Family CUCUMARIIDÆ Blainville, 1834

Genus CUCUMARIA Blainville, 1834

6. *Cucumaria analis* Vaney var. *sonoræ* Domantay
7. *C. crax* Deichmann var. *dotæ* Domantay

Genus LEPTOPENTACTA H. L. Clark, 1938

8. *Leptopentacta macullochæ* Domantay
9. *L. nova* Deichmann var. *colombiana* Domantay

Genus THYONE Oken, 1815

10. *Thyone colnettensis* Domantay
11. *T. ceciliæ* Domantay
12. *T. inermis* Heller var. *coronensis* Domantay
13. *T. turricata* Vaney var. *lourdesæ* Domantay

Order MOLPADIA Haeckle

Family GEPHYROTHURIIDÆ Deichmann

Genus GEPHYROTHURIA Koehler & Vaney, 1905

14. *Gephyrothuria veleroa* Domantay

Order ASPIDOCHIROTA Grube, 1840

Family SYNALLACTIDÆ Ludwig, 1894

Genus BATHYPLOTES Ostergren, 1896

BATHYPLOTES HANCOCKI Domantay.

Bathylotes hancocki DOMANTAY, Philip. Jour. Sci. 82 (1953) 136.

Body somewhat quadrangular in its preserved condition. Mouth partly terminal but ventral. Anus terminal. Tentacles partly retracted, apparently 20 peltate ones loaded with numerous spinous supporting rods giving extreme roughness to the touch and with a first impression that tentacles are calcified. Body-wall thick but somewhat gelatinous and slippery. In majority of specimens outer part of integument partly off leaving gelatinous portion. In some specimens where outer integument is intact, foreign matters like sand grains, etc. adhered closely to skin. Pedicels on trivium in double series along the three ambulacra, well-marked at median row. Some of warty excrescences terminating in a conical papillæ distinct on dorsal and lateral sides. Color in preserved state somewhat yellowish green.

Deposits: Tables of two sizes, small and large. Both have three or four pedal rods which bifurcate basally, ramify and anastomose with others, forming a circular disc of tables. From center of disc arises slender spinous spire. Majority of tables with incomplete disc appearing like some kind of tri- or tetra-

pods. In ventral perisome are tables with annular disc and single solid spire terminating in 4 spines. With other numerous irregular rods and tables. In dorsal perisome table resembles those of *B. patagiatus* Fisher with respect to disc but differ in spire which is a solid rod with spinous tip, almost similar with spire of tables from ventral perisome but bigger and without annular disc. With numerous supporting rods like those found in papillæ. Tables from distal part of papillæ resemble those from dorsal perisome and with numerous supporting rods. Large tables from proximal part of papillæ and from body-wall do not have prominent spires, but rather reduced to almost knoblike although the tri- and tetrapod-shaped disc almost resemble that of *B. patagiatus* Fisher. No C-shaped spicules have been encountered. Tentacles highly provided with numerous spinous supporting rods of different sizes, smallest at distal tips. Supporting rods of papillæ less spinous. Some of supporting rods of tentacles have side branches on outer curvature of rods, very prominent and ramify at distal tips. Pedicels with regular end-plate and numerous smooth long spindle-shaped supporting rods.

Type.—Holotype, AHF 1019–39.

Type locality.—N. of San Clemente Island.

Distribution.—Around Sta. Catalina Island and Gulf of California.

Depth.—300 fathoms.

Six other specimens were examined taken from five different stations.

BATHYPLOTES MACCULLOCHAE Domantay.

Bathyplotes maccullochæ DOMANTAY, Philip. Jour. Sci. **82** (1953) 136.

Body subcylindrical, measuring 110 mm long by 20 mm diam. Mouth ventro-terminal and anus dorso-terminal with 5 bilobed papillæ. With 20 medium size peltate tentacles. Pedicels robust and conical, scattered all over trivium and somewhat equidistant from each other although not in regular series. Papillæ rather small in contrast to pedicels and arranged in indistinct series all over the bivium. Body-wall hardier than that of *B. patagiatus* Fisher. Color dirty white or very light brown, much lighter on ventral side.

Deposits: Tables somewhat similar to the small with annular disc. of *B. hancocki.* Main difference in supporting rods of papillæ which are short, smooth rods of various sizes, some blunt

at both ends and others somewhat conical or pointed. Pedicels with pseudo end-plate composed of irregular tri- and tetra-radiate rods bifurcated at tips. Bigger tables without annular disc with tri- and tetra-radiate foot found on ventral body-wall together with some large rods somewhat racemose or dilated and perforated at both ends.

With the external difference in shape and in arrangement of pedicels and papillæ, the consistency of body-wall and difference in supporting rods of pedicles, it cannot be a variety of *B. hancocki* although taken from the same station.

Type.—Holotype, AHF–1306–41.

Type locality.—E. of Long Point, Sta. Catalina Island.

Distribution.—In type locality.

Depth.—228 to 267 fathoms.

BATHYPLOTES VELERONES Domantay.

Bathyplotes velerones DOMANTAY, Philip. Jour. Sci. **82** (1953) 136.

Small, apparently young, measuring 35 mm long by 8 mm diam. Body subcylindrical, slightly tapered at both ends. Mouth slightly ventral with around 20 peltate tentacles. Anus terminal. Pedicels scattered irregularly on ventral sides. Conical protuberances terminating in prominent papillæ found all over dorsal and dorso-lateral part of body, somewhat crowded in indistinct serial arrangement along both ambulacral and interambulacral areas. Color in preserved state brown but conical protuberances with papillæ white so the general coloration appeared somewhat mottled brown with white specks.

Deposits: Tables of two kinds, large and small, the latter more numerous. Small tables with circular disc and 8 marginal holes, with a spire of 4 rods and 2 cross beams. Large tables with disc composed of tetra-radiate pods, each dilated and perforated at ends and sometimes incompletely connected. Spire of two types, although usually composed of four rods, one type terminates in a cone giving a conical spire, the other terminates in a crown with around 8 spines and with from 3 to 4 crossbeams. Pedicels with regular end-plate and perforated supporting plates and rods.

Type.—Holotype, AHF 1724–49.

Type locality.—N. E. of Cape San Lucas (Lower California) Baja California.

Distribution.—In type locality.

Depth.—10 fathoms.

Order DENDROCHIROTA Grube, 1840

Family PHYLLOPHORIDÆ Grube, 1840

Genus ATHYONIDIUM Deichmann, 1941

ATHYONIDIUM DEICHMANNAE Domantay.

Athyonidium deichmannæ DOMANTAY, Philip. Jour. Sci. 82 (1953) 137.

Medium-sized form, biggest measures 60 mm long by 15 mm diam. at middle part of body. Body tapers toward both ends, usually J-shaped, longer limb bears 20 bushy tentacles of two sizes, 10 outer large ones and 10 inner small ones arranged in pairs at the ambulacral regions. Soft delicate pedicels numerous all over body, without end-plate and supporting rods. Anteriorly very prominent, arranged in double rows extending to introvert. Body color purplish brown throughout. With low simple calcareous ring, the radial plates with prominent anterior tooth.

Deposits: Body-wall devoid of calcareous deposits. Prominent anterior pedicels with large tables. Disk of table very delicate and spire composed of 4 rods which ramify distally. Tentacles with various types of rods, majority perforated and branched at both ends. Rosettes present.

Type.—Holotype AHF 1034–40.

Type locality.—Outer Gorda Bank, Gulf of California.

Distribution.—Type locality.

Depth.—64 to 95 fathoms.

Specimens examined.—The type composed of 61 specimens. Station 1752–49; 10 specimens.

Genus PHYLLOPHORUS Grube, 1840

PHYLLOPHORUS PANNINGI Domantay.

Phyllophorus panningi DOMANTAY, Philip. Jour. Sci. 82 (1953) 137.

Medium-sized form, measures 65 mm long by 12 mm diam. at middle part of body. Body tapers at both ends and slightly curved with a crescent-shaped form. Mouth terminal with introvert bearing 20 bushy tentacles of varying sizes, 5 pairs of unequal large ones alternating with 5 small pairs. Anal opening with 5 pairs of papillæ, apparently modified pedicels which marked the pentameral arrangement, although the pedicels are scattered all over the body without any definite arrangement. In the introvert with 5 double series of large and prominent pedicels. Color dark brown mottled with white specks representing the tips of pedicels. Introvert lighter in color.

Deposits: Numerous tiny irregular bodies of different forms from simple rod to buttonlike with 2 large lateral holes and small terminal ones. Intermediate forms double-edge wrench and incomplete button or rosette. Pedicels with large end-plate and numerous small irregular rods most of which perforated at both ends. Introvert with tables with reduced spire composed of two low rods. Disk with 4 central holes, lateral bigger than terminals, with 10 to 12 small marginals.

Type.—Holotype AHF 1076–40.

Type locality.—Tepoca Bay, Sonora, Mexico.

Distribution.—Type locality.

Depth.—Shore, Rocky reef.

Specimen examined.—The type 1 specimen.

Family CUCUMARIIDÆ Blainville, 1834

Genus CUCUMARIA Blainville, 1834

CUCUMARIA ANALIS Vaney var. SONORAE Domantay.

Cucumaria analis Vaney var. *sonoræ* DOMANTAY, Philip. Jour. Sci. **82** (1953) 137.

Small-sized form, measures 10 mm long by 3 mm diam. Body tapers at both ends, the anal end slightly turned upward, and anus with 5 anal papillæ. Both mouth and anus terminal. Tentacles slightly retracted, apparently with 10 equal bushy ones. Pedicels in distinct double series along each ambulacrum. Color dirty white.

Deposits: Numerous smooth irregular perforated plates and 6-holed, knobbed buttonlike plates with from 9 to 12 prominent marginal knobs. The presence of these 6-holed knobbed buttonlike plates with from 9 to 12 prominent marginal knobs differentiates it from the straight species, *Cucumaria analis* Vaney, apparently an Antarctic form so it may be possible that this new variety may turn out to be a new species. Pedicels without end-plate, with few spectacle-shaped supporting rods.

Type.—Holotype AHF 1088–40.

Type locality.—Ensenada de San Francisco, Sonora, Mexico.

Distribution.—Type locality.

Depth.—2 to 6 fathoms.

Specimen examined.—The type.

CUCUMARIA CRAX Deichmann var. DOTAE Domantay.

Cucumaria crax Deichmann var. *dotæ* DOMANTAY, Philip. Jour. Sci. **82** (1953) 137.

Small form, measures 15 mm long by 4 mm diam. Body pentameral with stout pedicels arranged in two irregular series along all ambulacral areas. Color light brown, darker at oral end. Tentacles retracted. Other features similar to straight species.

Deposits: Numerous, knobbed irregular-shaped buttons and rosettelike plates. Pedical with end-plate and large supporting tables, perforated at both ends and with prominent perforated spire.

Type.—Holotype AHF 1292–41.

Type locality.—S. Point, Sta. Rosa Is., California.

Distribution.—Type locality.

Depth.—30 fathoms.

Specimen examined.—The type.

Genus LEPTOPENTACTA H. L. Clark, 1938

LEPTOPENTACTA NOVA Deichmann var. COLUMBIANA Domantay.

Leptopentacta nova Deichmann var. *Columbiana* DOMANTAY, Philip. Jour. Sci. **82** (1953) 138.

Small-sized form, measures 33 mm by 5 mm diam. at middle. Mouth and anus terminal. Tentacles retracted. Body tapers at posterior end. Both ends slightly bent dorsad. Body rigid and tough. Conical papillæ apparently located on trivium only in single series along each of ventro–lateral ambulacra, although few indistinct ones may be recognized at both ends on bivium. Cobblestonlike scabs more conspicuous and regular. Color in preserved state uniformly white, slightly yellowish at both ends. Much bigger than the straight species.

Deposits: Similar to those of the straight species except that minute perforated biscuit-shaped deposits are replaced by delicate tables with reduced spire and irregular disk with from 3 to 5 holes.

Type.—Holotype AHF 408–35.

Type locality.—Gorgonia Island, Columbia.

Distribution.—Type locality.

Depth.—65 to 80 fathoms.

Specimen examined.—The type.

LEPTOPENTACTA MACCULOCHAE Domantay.

Leptopentacta macculochæ DOMANTAY, Philip. Jour. Sci. **82** (1953) 138.

Small-sized form, measures 20 mm long by 5 mm diam. Body pentameral, posterior end turned dorsad. Mouth terminal. Thir-

teen tubular tentacles, 8 large ones and 5 small, one to each ambulacrum, alternating with a pair of larger tentacles, two of which are unpaired and interambulacral in position. Pedicels apparently nonretractile, those of two dorsal ambulacra in single series, and those of three ventro-lateral ambulacra in zigzaggy rows. Body integument tough and stiff due to numerous deposits. Color yellowish white. Somewhat mosaic due to large cobblestonelike plates.

Deposits: Numerous swollen or slightly knobbed perforated plates and reticulated bodies. Pedicels with rudimentary end-plate and spectacle-shaped supporting rods, some irregular and perforated plates.

Type.—Holotype AHF 1213–40.

Type locality.—San Pedro Channel, California.

Distribution.—Type locality, Laguna Beach and Gulf of California.

Depth.—114 to 131 fathoms.

Specimens examined.—The paratypes 1214–40, 1130–40, 1084–40.

Genus THYONE Oken, 1815

THYONE TURRICATA Vaney var. LOURDESAE Domantay.

Thyone turricata Vaney var. *lourdesæ* DOMANTAY, Philip. Jour. Sci. 82 (1953) 138.

Small-sized form, the biggest measures 15 mm long by 7 mm diam. at middle. Tapers at both ends and smaller and conical at anal end; with 10 slightly pinnate or bushy tentacles, 2 of which are small. Pedicels in double series along ambulacral region and few on inter-ambulacral area. Body-wall white and somewhat transparent. Anal end always turned upward.

Deposits: Perforated and partly spinous plates of various sizes and irregular shapes. Small serrated rosettelike rods and simpler ones dilated and perforated at both ends, and small irregular rosettes of various forms. Conical anal end resembling a tail stiffened with numerous large saddle-shaped perforated plates, the base of which fits with curvature of tail-like anal end and distal half free and overlaps with preceding and succeeding plates. Pedicel with end-plate. Tentacles with slender supporting rods finely perforated at both ends.

Type.—Holotype AHF 1412–41.

Locality.—S. Crook Point, S. Miguel Island, California.

Depth.—41 to 43 fathoms.

Specimen examined from 17 stations.

THYONE INERMIS Heller var. CORONENSIS Domantay.

Thyone inermis Heller var. *coronensis* DOMANTAY, Philip. Jour. Sci. 82 (1953) 138.

Body fusiform and attenuated toward both ends. Posterior end appears like a short tail partly bent ventrad. Body-wall thin, delicate slippery and transparent, not exactly devoid of calcareous deposits. Pedicels appear like tiny specks scattered irregularly in interambulacral area. Tentacles small and partly contracted. Five radial longitudinal muscles together with intestine visible externally.

Deposits: Few tiny smooth rods, some bifurcated at one end, others tri-radiate but majority straight or twisted smooth rods, apparently fragments of irregular crown-shaped spicules, found at caudal end.

Type.—Holotype AHF 1457–42.

Specimen examined.—The type.

THYONE COLNETTENSIS Domantay.

Thyone colnettensis DOMANTAY, Philip. Jour. Sci. 82 (1953) 138.

Small-sized form, measures 12 mm long by 4 mm diam. Body slightly curved dorsad with both oral and anal ends somewhat blunt although taper slightly. Somewhat pentameral with double series of stout pedicels along all ambulacra. Tentacles retracted. Body-wall hardy. General color brown with numerous specks of darker coloration.

Deposits: Tables with reduced spire, disk with 4 central holes and from 4 to 12 small peripheral ones. In well developed disk where 12 small marginal holes are found, the 2 centro-terminals appear to be with the rest leaving 2 large centrals. Spire reduced to 2 rudimentary pillars appearing just like knobs. Pedicels with end-plate and numerous elongated lozenge-shaped supporting tables with reduced knoblike spire. With 4 holes at middle, the lateral much bigger than terminals.

Type.—Holotype AHF 1688–49.

Type locality.—Colnett Bay, Lower California, Mexico.

Distribution.—Type locality.

Depth.—6 fathoms.

Specimen examined.—The type.

THYONE CECILLAE Domantay.

Thyone cecillæ DOMANTAY, Philip. Jour. Sci. **82** (1953) 138.

Small-sized form, biggest measures 10 mm long by 3 mm diam. Body somewhat pentamerical with double series of pedicels along each of five ambulacra. Pedicels not crowded and well spaced. Body-wall wrinkled apparently due to contraction. With double set of anal papillæ. Tentacles retracted.

Deposits: Numerous tables with somewhat regular disk, the two central holes exceptionally large compared with other ones. Number of smaller holes not constant. Pedicel with starlike end-plate of 6 to 9 rays, and supporting perforated rod and table.

Type.—Holotype AHF 1295–41 (10 specimens).

Type locality.—Sta. Cruz Island, California.

Depth.—15–21 fathoms.

Specimens examined.—The type (10 specimens).

Order MOLPADIA Haeckle

Family GEPHYROTHURIIDÆ Deichmann

Genus GEPHYROTHURIA Koehler & Vaney, 1905

GEPHYROTHURIA VELEROA Domantay.

Gephyrothuria veleroa DOMANTAY, Philip. Jour. Sci. **82** (1953) 139.

Body somewhat subcylindrical, wrinkled and compressed as if eviscerated apparently due to absence of deposits. Body measures 110 mm long by 20 mm wide by 10 mm depth in preserved state. Ventral side somewhat like a regular groove due apparently to state of contraction. Numerous foreign bodies from sand grains to sponge spicules attached or stuck to ventral body-wall. With 13 peltate tentacles, mouth ventral and anus terminal. Color grayish brown on ventral and yellowish brown on latero-dorsal side. No pedicels nor papillæ.

Calcareous ring simple and massive. With 1 Polian vesicle. Respiratory tree with a common stalk and divided into two main branches, each branch divided again into two sub-branches. Each sub-branch give short irregular branches with bunches of short blunt ends.

Deposits: No calcareous deposits on body-wall. Tentacles with irregular-shaped rods, from simple to branched without any definite pattern, somewhat spinous.

Type.—Holotype AHF 1306–41.

Type locality.—Santa Catalina Island.

Distribution.—Type locality.

Depth.—228–380 fathoms.

Specimens examined.—The type, 3 specimens; paratype 1156–40, 1 specimen; paratype 1166–40, 2 specimens.

BIBLIOGRAPHY

BELL, F. J. Echinodermata: Report on the zoological collections made in the Indo-Pacific Ocean during the voyage of H. M. S. "Alert" 1881–82, London, 1884c.

BRANDT, T. Fr. Prodromos description animalium ab H. Mertensie in orbis terrarum circumnavigatione observatorum, Petersburg, Heft 1 (1835).

CHAMISSO, A., and C. G. EYSENHARDT. De Animalibus duce Ottone de Ketzebue observatis. Act. Akad. Germ. (1821).

CHIAJE, St. Delle. Memorie sulla steria et notonia degli animali senza vertebre del regne Napoli 1–4 (1823–1829).

CLARK, H. L. Notes on the Bermuda echinoderms. New York Acad. Sci. Ann. **11** (1898).

CLARK, H. L. Further notes on the Bermuda echinoderms. New York Acad. Shi. Ann. **12** (1890).

CLARK, H. L. The apodous holothurians—a monograph of the Synaptidæ and Molpadidæ, etc. Wash. D. C., Smith. Inst. Cont. to Knowledge **35** (1907).

CLARK, H. L. The echinoderm fauna of Torres Strait; Its composition and its origin. Carnegie Inst. Wash. Dept. Mar. Biol. papers **10** (1921).

CLARK, H. L. The holothurians of the genus Stichopus. Mus. Comp. Zool. Bull. **65** (1922).

CLARK, H. L. Notes on a collection of echinoderms from the Australian Museum, Sidney, Australia, Museum, Records No. 215 (1926).

CLARK, H. L. Echinoderms from Australia. Mus. Comp. Zool. Mem. **55** (1938).

DEICHMANN, E. Holothurians from the Gulf of California. The templeton Croaker Expedition, 9 Zoologica **22** (1937).

DEICHMANN, E. Holothurians from the western coast of Lower California and Central America, and from the Galapagos Islands Eastern Pacific Expeditions of the New York Zoological Society, 16. Zoologica (4) **23** (1938).

DEICHMANN, E. The Holothurians of the western part of the Atlantic Ocean. Mus. Comp. Zool. Bull. (3) **71** (1930).

DEICHMANN, E. The Holothurioidea collected by the Velero III and IV during the years 1932 to 1954. Pt. II. Aspidochirota, Univ. So. Calif. Press, L. A., Calif. (1958).

DOMANTAY, J. S. Littoral Holothurioidea of Port Galera Bay and adjacent waters. U.P. Nat. Applied Sci. Bull. **3** (1933).

DOMANTAY, J. S. Four additional species of littoral Holothurioidea of Port Galera Bay and adjacent waters. U.P. Nat. Appleid Sci. Bull. **4** (1934).

DOMANTAY, J. S. Some holothurians from Guam and vicinity. U.P. Nat. Applied Sci. Bull. (4) **12** (1954) 336–357.

DOMANTAY, J. S. A brief summary of the Pacific and Atlantic Holothurioidea of the Allan Hancock Foundation collections. Philip. Jour. Sci. **82** (1953) 133–140.

DOMANTAY, J. S. Littoral holothurians from Zamboanga and vicinity. Philip. Jour. Sci. **82** (1953) 109–131.

DOMANTAY, J. S. The zoogeographical distribution of the Indo-Pacific littoral Holothurioidea. Proc. Eighth Pacific Science Congress. Nat. Res. Council of the Philippines, 1957.

DOMANTAY, J. S. Preliminary report on the marine fauna of One Hundred Islands and vicinity, Gulf of Lingayen, Pangasinan Province, Luzon, Philippines. Araneta Jour. Agr. (1) **4** (1957).

DOMANTAY, J. S. Some holothurians from Florida in the collection of the Allan Hancock Foundation. Agra Univ. Jour. Res. (Science), Agra. India pt. 2 **7** (1958) 181–202.

FISHER, W. K. The holothurians of the Hawaiian Islands. U. S. Nat. Mus. Proc. **32** (1907).

HEDING, S. G. Contribution of the knowledge of Synaptidæ. I. Vidensk Medd. fra Dansk naturgh. Foren. **88** (1929).

HEDING, S. G. Echinoderm III. Holothurioidea 2 (Fam. Synaptidæ) Beitrage zur Kenntnis der Meeres fauna Westafrikus (7) **3** (1932).

HEDING, S. G., and A. Panning. Phyllophoridæ eine bearbeitung der Polytentaculaten Dendrochiroten Holothurien des Zoologischen Museums in Kopenhagen. Spolia zoologica Musei Hauniensis **13** (1954) 7–209.

JAEGER, S. F. De holothuriis. Diss. inaug. Turici. 1833.

KENT, W. S. Beche-de-mer Fisheries. The Great Barrier Reef of Australia; Its Products and Potentialities. W. H. Allan and Co., Calcutta (1893).

KOEHLER, R. Echinoderms de la Baie d'Amboine. Rev. Suisse de Zool. **3** (1895).

KOEHLER, R., and C. Vaney. An account of the littoral Holothurioidea. Echinoderms of the Indian Museum, Calcutta (1908).

LUDWIG, H. The Holothurioidea; in reports on an exploration off the west coast of Mexico, Central and South America, and off the Galapagos Islands, in charge of Alexander Agassiz, by the U. S. Fish Commission Steamer "Albatross" Nr. 12. Mus. Harvard Coll. Mem. (3) **17** (1894).

LUDWIG, H. List of the holothurians in the collection of the Leyden Museum. Notes Leyden Museum (10) **4** (1882).

LUDWIG, H. Die von Dr. J. Brook in Indischen Archipel gezalmelten Holoturien. Zool. Jahrb. **3** (1888).

MITSUKURI, K. A list of holothurians known to occur in Japan. Zool. Mag. **8** (1896).

MITSUKURI, K. Studies on Actinopodus Holothurioidea. Imperial Univ. Tokyo, Jour. Coll. Sci. (2) **29** (1912).

MORTENSEN, T. Echinoderms of New Zealand and the Auckland-Campbell-Island. III-V, Vidensk Medd. Dansk Naturg, Foren. **79** (1925).

OSTERGREN, H. Uber eine durchgreifende Urwandlung des Hautskeletts bei Holothuria impatiens (Forskål). Zool. Anzeig. **21** (1898).

OSHIMA, H. The synaptidæ of Japan. Annot. Zool. Jap. **8** (1914).

OSHIMA, H. Report on the holothurians collected by the Albatross, etc. U.S. Nat. Mus. Proc. **48** (1915).

PANNING, A. Echinoderm III. Holothurioidea I (Fam. Holothuriidæ); in Michaelsen, W. Beitrage zur. Kenntnis der Meeresfauna Westafrikus (5) **3** (1928a).

PANNING, A. Uber das optische Verhatten der Kalkkorper der Aspidochiroten Holothurien. Zeit. Wiss. Zool. **132** (1928b).

PANNING, A. Zur Kristalloptik der Kalkkorper der appidochiroten Holothurian. Zool. Mus. Hamburg Mitt. Zool. Staats-inst. **44** (1929).

PANNING, A. Die Gattung holothuria. Mitt. a.d. Zool. Staat. u. Zoolog. Mus. Hamburg. (1) **44** (1929).

PANNING, A. Uber die Kristalloptik der Kalkkorper der Seewelsen. Zool. Jahrb. (2) **49** (1931).

PANNING, A. Die Gattung Holothuria. (2 teil) Zoolog. Mus. Hamburg. Mitt. a.d. Zoolog. Staat. **45** (1934).

PANNING, A. Die Gattung Holothuria. (3 Teil) Zoolog. Mus. In Hamburg Mitt. a.d. Zoolog. Staat. **45** (1934).

PANNING, A. Die Gattung Holothuria. (4 Teil) Zoolog. Mus. in Hamburg Mitt. a.d. Zoolog. Staat **45** (1935).

PANNING, A. Die Gattung Holothuria. (5 Teil) Zoolog. Mus. in Hamburg Mitt. a.d. Zoolog. Staat **46** (1935)

PANNING, A. Uber einige Ostafrikanische Seewalzen U. ihre eighnung zur Trepanggewinnung. Thalassia (8) **4** (1954) 3–18.

PANNING, A. Die Trepangfischerie. Sonderuck aus: Mitt. aus dem Hamburgischen Zoologischen Museum and Institute in Hamburg **49** (1944) 1–76.

PEARSON, J. Notes on the Holothurioidea of the Indian Ocean. I. The genus Holothuria. Spolia Ceylanica **9** (1913).

PEARSON, J. Proposed reclassification of the genera (Mulleria and Holothuria, Spolia Ceylanica **9** (1914a).

PEARSON, J. Notes on the Holothurioidea. II. The sub-genera Argiodia and Actinopyga. Spolia Ceylanica **9** (1914b).

PEARSON, J. Report on the Holothurioidea, collected by Prof. Herdman at Ceylon, in 1902; in Herdman, W. A., Report to the Government of Ceylon, on the pearl oyster fisheries of the Gulf of Manaar. Teil 1, Suppl. **5** (1903).

SAVILLE-KENT, W. The Great Barrier Reef of Australia; Its Products and Potentialities London (1893).

SELENKA, E. Beitrage zur Anatomie and Systematik der Holothurien. Zeit. Wiss. Zoolog. **17** (1867).

SELENKA, E. Nachtrag zu den Beitragen zur Anatomie und Systematik der Holothurien. Zeit. Wiss. Zool. **18** (1868).

SEMPER, C. Holothurien. Reisen im Archipel der Philippinen, Teil 2, Wiss. Res. Leipzig **1** (1868).

SIVICKIS, P. B., and J. S. DOMANTAY. The morphology of a holothurian, Stichopus chloronotus Brandt. Philip. Jour. Sci. **37** (1928).

SLUITER, C. P. Holothurien des Java-Meeres. Nat. Tijd. v. Nederlandisch-Indie **47** and **49** (1887–90).

SLUITER, C. P. Die Holothurien der Siboga-Expedition. Monographie **44** (1901).

THEEL, H. Report on the Holothurioidea dredged by H. M. S. Challenger during the years 1873–76, II; in the Voyage of H. M. S. Challenger, Zool. 14 2 Addenda in 14 1 (1886a).

VANEY, C. Holothuries recueillies sur la Cote Francaise des Somalis. Mus. d'Histoire Nat. Bull. 11 (1905).

VERRIL, A. E. Additions to the Fauna of the Bermudas from the Yale Expedition of 1901, with notes on other species. Connecticut Acad. Arts. Sci. Trans. 11 (1902).

WHITELEGGE, T. The Echinodermata of Funafuti; in: the Atoll of Funafuti. Austral. Museum Mem. 3 (1897).

PREPARATION OF STARCH FROM BINLID (BROKEN RICE)

By Felicidad Estores Anzaldo, Aurelio O. Cruz, and Florecilla C. Borlaza

National Institute of Science and Technology, Manila

Starch is one of the many products which we consume daily in great quantities. Its utilization ranges from the simple household uses to the more complex industrial applications; e.g., cooking, laundering, and the manufacture of pharmaceuticals, dusting powder, dextrin, glucose, baking powder, paper, asbestos, adhesives, soap, textiles, and confectionery.

The object of this study is to find out the best method of preparing starch from *binlid* or broken rice. Binlid was chosen because this raw material is locally available, cheap, and abundant. The large-scale production of starch of the desired quality from binlid at a cost that is lower than the lowest prevailing would be a step forward in achieving self-sufficiency for the country.

EXPERIMENTAL

Broken rice was obtained directly from the mill to have the more-or-less pure form. Four methods of producing starch were tried; namely, (*1*) the Das Gupta method; (*2*) the L. L. Wood method, which uses 40 per cent solution of potassium thiocyanate; (*3*) the H. Bader fermentation method; and (*4*) the F. B. Wise method.

Das Gupta method.—Powdered binlid was allowed to pass through a 100-mesh sieve and steeped in 0.5 per cent caustic soda solution. The pasty mass thus obtained was allowed to stand from 48 to 54 hours, with stirring at intervals. It was afterwards diluted with water to a thin suspension and centrifuged for 15 minutes. The supernatant liquid was decanted and the two layers of starch which settled at the bottom were separated carefully and washed repeatedly.

The two grades of starch thus obtained were suspended separately in water, centrifuged repeatedly at 2,000 r.p.m., and the supernatant liquid decanted on each occasion. The resulting precipitates were dried under the sun or at a temperature be-

low 50°C. The starch that settled at the bottom was cleaner than that in the upper layer.

Wood method.—Binlid which was previously dried was finely ground and 40 per cent solution of potassium thiocyanate added. This mixture was heated in a water bath at 50° to 60°C and vigorously stirred for 2 hours. It was then centrifuged and the supernatant liquid, which was the KSCN-starch solution, was treated with 95 per cent ethyl alcohol. The starch precipitated in the form of snow-white aggregates. Separation was effected by centrifuging and washing, first with portions of alcohol and then with cold distilled water. The resulting starch was then dried.

Bader method.—This method does not require any special apparatus. Grinding of the rice grain is not necessary. With 5 grams carbonate of lime per 100 grams rice in an aqueous medium at a temperature of 30°C, the rice grains were made to undergo fermentation. Starch was isolated by decantation.

Wise method.—The broken rice was steeped in a 0.3 per cent solution of NaOH with 1 part rice to 5 parts alkaline solution. After 24 hours' standing, the alkaline solution was drawn off and the rice washed twice. The drained rice was dried and ground. The fine flour obtained was carefully stirred into ten times its weight of alkaline water and the stirring continued for 24 hours. The starch was allowed to settle in 70 hours, and the upper liquor was siphoned off. Pure water twice the volume was added and the whole agitated. After a few hours, standing to remove heavy particles, the starch milk was removed. Settling and washing followed until the starch was freed of impurities. The starch was then dried.

RESULTS AND DISCUSSION

Das Gupta method.—This method yielded 81.5 per cent starch. The starch which settled as the bottom layer was cleaner, whiter, and purer than the top layer. The bottom layer was 93.85 per cent pure (on moisture-free basis) while the top was 71.72 per cent.

An analysis of the starch in the top and bottom layers showed the following:

	Bottom layer	Top layer
	Per cent	*Per cent*
Moisture	11.76	10.84
Protein	6.78	19.78

	Bottom layer	Top layer
	Per cent	*Per cent*
Ash	0.48	0.38
Total reducing sugar	4.95	3.54
Crude fat	0.085	0.22

The experiments were carried out with two varieties of rice (Wagwag and Quezon) which are available locally. The results obtained from them showed no appreciable difference.

It can be observed that this is quite an inexpensive method as only a little amount of caustic soda was used in the steeping of the rice powder. Furthermore, only water was used for washing the product before drying.

Wood method.—This method is quite expensive because alcohol was used for precipitating the starch and also for washing it. The experiment was done twice but the product obtained each time was a gelatinous mass which when dried became hard and could not be powdered easily. The material should be finely powdered and the temperature must be well controlled in order to get a very good product.

Bader method.—This method requires a long time in steeping in order to effect fermentation. The method is delicate and should be done under anærobic conditions. It needs an apparatus which would help in the rapid separation of starch from the rice grains.

Wise method.—This method, which is quite similar to the Das Gupta, is similarly inexpensive. The product obtained was good. For every 100 grams broken rice, 75.4 grams starch was obtained, representing 75.4 per cent yield.

SUMMARY

Starch was extracted from *binlid* (broken rice) with the use of four different methods; namely, the (*1*) Das Gupta method, (*2*) L. L. Wood method, (*3*) the Bader fermentation method, and (*4*) the F. B. Wise method. Analyses were made of the final products. The Das Gupta and the Wise methods gave satisfactory results. The Das Gupta method, however, is to be preferred because it is more economical. The yield of starch through this method was 81.5 per cent; through the F. B. Wise method the yield was only 75.4 per cent.

REFERENCES

1. BADER, H. Sur un procede simple d' extraction de l' amidon du riz Tonkin. Chimie und Indust. (4) **32** (1934) 911.

2. BRAUTLECHT, Charles Andrew. Starch; its sources, production, and uses. New York, 1953.
3. DAS GUPTA, H. P. Preparation of starch from indigenous grains and tubers. Agriculture and Livestock in India **4** (1934) 645–651.
4. DAS GUPTA, H. P. Preparation of starch from indigenous grains and tubers. Indian Inst. Sci. **190** (1936) 34–36.
5. GILL, K. Separation of starch by elutriation. Jour. Sci. Indust. Res. (10) **13** B (1954) 96–99.
6. KERR, RALPH W. Chemistry and industry of starch, starch sugars, and related compounds. Starch (1944).
7. TORRES, FERNANDO S. The Manufacture of cassava starch. Stockm. Farm. (4) **2** (1935) 15–17.
8. WISE, F. B. The Manufacture of starch from rice. Bull's Eye Assoc. Rice Mill. **1** (1921) 18–20.
9. WOODS, L. L. Extraction of starch from dried materials. Chem. Analyst. (2) **30** (1941) 45.

STUDIES ON THE PREPARATION OF MANGO JUICE POWDER

By Estelita M. Payumo, Peregrino H. Quinitio, and Alicia L. Lingao
National Institute of Science and Technology, Manila

In the field of food technology, the preparation of concentrated and dehydrated products is gaining wide importance. Preservation by drying is the oldest method of food preservation but it has proven to be difficult to apply to fruit juices because they contain a large proportion of hygroscopic sugars. Powdered fruit juices have been the object of considerable interest during the past few years. The U.S. Army Quartermaster Corps and the Armed Forces of the Philippines are particularly interested in the use of fruit powders as fruit drink after reconstitution because of their light weight and excellent keeping qualities. Such powders have a distinct advantage over high density liquid concentrates in regard to keeping properties at elevated temperatures especially in the tropics.

In keeping with the ever-increasing importance of concentrated and dehydrated products, the preparation of fruit juice powders using local fruits of the Philippines is now being studied. This paper reports our studies on the preparation of powdered mango, the feed preparation or concentrate, drying technique and packaging.

Mango is a delicacy in the Philippines and is considered the most delicious of all Philippine fruits. It is seasonal in nature, although some off-season fruits are available in some parts of the Islands. Off-season fruits are generally not as delicious as those gathered during the season and are so expensive that they are not within the reach of the majority of the population.

Mangoes are generally eaten fresh. However, they have also been used on a limited scale in the production of jams, jellies, candies or preserved halves and slices in sugar syrup.[1] Canned mango juice is now being produced commercially by one local food manufacturing plant.

So far no published studies on the dehydration of local fruit juices are available, hence, this study on mango dehydration.

[1] Orosa, M. Y., Preservation of Philippine Foods. Bur. Sci. Pop. Bull. 1 (1926) 12.

Mango has been chosen as the first material in this series of studies owing to its delicious flavor and wide acceptability as food both to the Filipinos and foreigners alike.

In-package desiccation, developed during World War II for increasing the storage stability of dehydrated vegetables, is indispensable in the preparation of stable juice powders.[2] It has proven extremely successful in bringing the moisture level of dehydrated products to a very low level at moderate cost and with no product deterioration. Calcined lime has excellent water-vapor capacity and therefore is more extensively used for in-packaged desiccation (IPD).

MATERIALS AND METHODS

Preparation of feed material.—Only sound, mature and ripe mangoes were used. The fruits were thoroughly washed, peeled, and the edible portion removed and scooped out of the seed. The edible portion or pulp was crushed in a Waring Blendor for complete disintegration. The crushed pulp contains 21 per cent soluble solids (Zeiss Opton refractometer). Sugar was added in varying proportions, from 0 to 75 per cent by weight of the pulp and a fruit acid, citric acid, was added to give a palatable sugar-acid ratio. After thorough mixing, the pulp concentrate was ready for drying. The pulp concentrate had a final concentration range of 21 to 54 per cent soluble solids.

Drying.—The drying operation was carried out in a laboratory vacuum oven under a vacuum of 27 inches of mercury. The concentrate was poured evenly over the surface of shallow aluminum trays to obtain a film approximately one-eighth inch in thickness. The pans had been previously coated with a thin film of appropriate wax (such as Johnson's Corrosive Inhibitor Wax[3]) so that the material could be easily removed after drying. The trays were then placed on the shelves of the drier and heated to a temperature not exceeding 65°C and maintained at a vacuum of 27 inches of mercury. During the drying, the product showed evidence of bubbling as shown by the increase in depth of the dried product. The drying was continued until a sufficiently dry product of about 1 to 2 per cent moisture was obtained. After completion of the drying, the product was in a molten state. It was, therefore, thoroughly cooled before grinding to

[2] Howard, L. B., Desiccants Improve Dry Pack. Food Packer **26** (1945) 31.

[3] Mention of a commercial product does not necessarily mean the endorsement of the said product by the agency.

render the product brittle. The product was ground so as to pass a 10-mesh screen. This grinding was done in a low-humidity (12 per cent RH) room because of the hygroscopicity of the product. An air-conditioned room maintained at 26°C served the purpose.

Packaging.—To keep moisture content extremely low, thus preventing caking during storage and prolonging shelf life, the product was packed in jars or hermetically sealed in cans with an envelope containing a desiccant.[4] The weight of the desiccant was approximately one-tenth the weight of the powder.

Reconstitution.—To obtain a beverage of approximately 15° Brix, one part by weight of the powder is dissolved in five parts of water.

RESULTS AND DISCUSSION

Results of the study show that one-half to three-fourths parts by weight of sucrose added to the pulp gave the most desirable flavor and sweetness. The final concentration of the feed material was between 48° to 54° Brix. Citric acid was added to the extent of 0.1 per cent to obtain a palatable sugar-acid ratio. Final moisture content of dried powder was maintained at 1 to 2 per cent to facilitate grinding. The product was ground to a granular powder so as to have a coarse structure because fine grinding increases tendency of the dried product to cake and form lumps during long storage.

To increase storage life, the finished powder is packed in containers with a sufficient quantity of desiccant. This desiccant, usually calcium oxide or calcium hydroxide, absorbs residual water from the product by in-package desiccation and thereby lowers the moisture content to the required level of less than 1 per cent.[5]

The reconstituted product has a color, flavor and aroma similar to that of the fresh juice. Besides its use for reconstitution to beverage drinks, the powder can be used to contribute natural flavor to ice-creams, candies, dessert and cake mixes and other food preparations where fruit flavors are needed.

Because of its extremely low moisture content, the powder

[4] Howard, L. B., op. cit.

[5] Tressler, D. K., and M. A. Joslyn. The Chemistry and Technology of Fruit and Vegetable Juice Products. The Avi Publ. Co., Inc., New York (1954).

has kept satisfactorily for over six months at room temperature (30°C).

SUMMARY

Mango juice powder has been prepared by dehydrating mango juice containing 21 to 54 per cent soluble solids to a dried product with about 1 to 2 per cent moisture in a laboratory vacuum oven. Drying was carried on at a temperature not exceeding 65°C and maintained at 27 inches of vacuum. The dried product is ground to pass a 10-mesh screen and packed with an in-packaged desiccant to prevent lumping.

ACKNOWLEDGMENT

The authors wish to express their appreciation for the helpful comments and suggestions received from Dr. C. R. Pascual, research director, FNRC, and to the members of the technical committee of the Food and Nutrition Research Center, National Institute of Science and Technology, in the preparation of this paper.

SEROLOGICAL REACTIONS AMONG LEPERS

By Virginia Basaca-Sevilla
Bureau of Research and Laboratories, Manila

The laboratory has always been bothered by reactions of diseases other than syphilis to the ordinary serological tests, like Kahn, VDRL and Kolmer. This is specially so when negative serological reactions are required for those going abroad on a fellowship, for job applicants, temporary visitors and immigrants. Very few of those found reactive to these tests admit exposure to syphilis. Leprosy is one of the diseases that was claimed to give biologic false positive reactions. This study was conducted to determine (*1*) the extent the disease itself will give a reactive reaction; (*2*) the relation of the stage and type of disease to the serological results; and (*3*) the best available test to employ among lepers for the detection of syphilis.

MATERIALS AND METHODS

Leprosy cases gathered from June 1958 to December 1960, totalling 819 patients came from the Manila Skin and Tumor Clinic and the Central Luzon Leprosarium in Tala, Novaliches, were made subjects of this study. Patients from the clinic were sent directly to the laboratory where they were bled. The cases from the leprosarium were bled by the staff of the leprosarium and the blood sent to our laboratory the same day. All samples were subjected to the routine serological procedures mentioned below.

The procedures followed in the performance of the serologic tests—Kahn, VDRL and Kolmer—were those published in the Manual of Serologic Tests for Syphilis,[1] 1955 and 1959, except for some details mentioned below.

Kahn test: The antigen employed in this test was prepared from beef heart at our laboratory.

VDRL slide flocculation test: The antigen used is the cardiolipin antigen for microflocculation manufactured by Sylvana Chemical Company. This antigen is used by the U.S. Army Medical Service Graduate School.

[1] Manual of Serologic Tests for Syphilis, 1955. U.S. Dept. of Health Ed. and Welfare.

Kolmer test: The antigen used in this test is the cardiolipin antigen for complement-fixation test for syphilis manufactured by Sylvana Chemical Company and used by the New York State and U.S. Army Medical Service Graduate School. The hemolysin and complement were prepared by our laboratory. Sheep's cells preserved in Alsever's solution were used in the test. Instead of the regular Kolmer saline a Veronal buffered saline was used.

RESULTS AND DISCUSSION

Of the 819 leprosy patients studied, 719 were tuberculoid and dispensary cases and 100 were lepromatous patients confined in the leprosarium at Tala. Results are given in four tables.

TABLE 1.—*Reactions of 719 tuberculoid lepers to Kahn, VDRL and Kolmer tests.*

Reactions	Serological test					
	Kahn		VDRL		Kolmer	
	Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
Reactive	46	6.39	14	1.94	19	2.64
Weakly reactive	16	2.2	9	1.25	—	—
Nonreactive	657	91.3	696	96.8	700	97.3

TABLE 2.—*Reactions of reactive* tuberculoid cases to one or more serological tests.*

Reaction	Number	Per cent
Reactive to Kahn test alone	42	63.6
Reactive to Kahn and VDRL tests	3	4.54
Reactive to Kahn and Kolmer	1	1.5
Reactive to Kahn, VDRL and Kolmer tests	15	22.7
Reactive to VDRL test alone	2	3.0
Reactive to Kolmer test alone	1	1.5

* Includes reactive and weakly reactive cases.

TABLE 3.—*Reactions of 100 lepromatous cases to Kahn, VDRL and Kolmer tests.*

Reactions	Serological tests		
	Kahn	VDRL	Kolmer
	No. or per cent	*No. or per cent*	*No. or per cent*
Reactive	52	4	3
Weakly reactive	19	2	—
Nonreactive	29	94	96
Anticomplementary	—	—	1

TABLE 4.—*Reactions of reactive* lepromatous cases to one or more serological tests.*

Reactions	Number or Per cent
Reactive to Kahn test alone	66
Reactive to Kahn & VDRL tests	3
Reactive to Kahn & Kolmer tests	0
Reactive to Kahn, VDRL & Kolmer tests	3
Reactive to VDRL test alone	0
Reactive to Kolmer test alone	0

* Includes reactive and weakly reactive cases.

TABLE 5.—*Comparative reactions in percentage of the tuberculoid and lepromatous groups to Kahn, VDRL and Kolmer tests.*

Reactions	Serological tests					
	Kahn		VDRL		Kolmer	
	Tuberculoid	Lepromatous	Tuberculoid	Lepromatous	Tuberculoid	Lepromatous
Reactive	8.62	71.0	3.19	6.0	2.64	3.0
Nonreactive	91.3	29.0	96.8	94.0	97.3	96.0
Anticomplementary	—	—	—	—	—	—

We deemed it wise to seek close cooperation with the staff of the Division of Sanitaria in having patients in this study clinically divided into two groups—tuberculoid and lepromatous. There were a number of studies along this line but the work in most of them was confined to lepers as a single group. Tables 1 and 3 clearly show the difference of the reaction of the two groups in Kahn test. While only 8.62 per cent of the 719 tuberculoid lepers gave a reactive result (includes reactive and weakly reactive), a high percentage of reactivity, 71 per cent, was given by the lepromatous group. The figures for the reaction to Kahn test clearly show why these two types of leprosy should not be mixed.

In serology, in order to make the results of different workers reasonably comparable all must be obtained with the use of the same procedure and the same antigens and reagents. This is not so with studies of the leper group among different workers. Zarco and Chan[2] worked with a group of 108 patients; of these, 97 were typed to be mixed cutaneous, 1 cutaneous, 9 tuberculoid

[2] Phil. Med. Assoc. **34** (1958).

and 1 unspecified. They obtained 3.7 per cent reactivity with the complement-fixation test and 26.8 per cent with the VDRL slide flocculation test. It is only with the complement-fixation test that a similarity of results were obtained, considering that they used the same antigent as we did but followed the c–f technique of the New York State Department of Health with a spectrophotometric reading of results. Our figures of reactivity with the complement-fixation test is 2.64 per cent for the tuberculoid and 3 per cent for the lepromatous group as compared with their 3.7 per cent for the lepers as a group.

Rodriguez[3] mentioned that the sera from 18 patients with tolondrons, a form of lepra reaction in lepromatous leprosy, were examined by Kahn test. Six gave positive titers, one of them had syphilis and none had yaws. In this series we have 13 patients of a group of 50 bled in one day with ENL lesions. Of these, 8 were reactive to Kahn, three were weakly reactive and two were negative. The highest titer obtained was 64 dils in one patient.

J. O. de Almeida[4] worked on 467 cases of lepromatous leprosy. Of these 65 per cent reacted with Kahn, 36 per cent with VDRL, and 16.8 per cent with Kolmer c–f technique. Comparing our figure for Kahn, which is 71 per cent, with Almeida's 65 per cent, the difference is slight. It, however, widens when the figures for the cardiolipin antigens are compared; although Almeida obtained a lesser seroactivity also with the Kolmer c–f technique.

We further compared our results with the results of tests obtained from nonleprous groups, utilizing data from a yet unpublished work.

TABLE 6.—*Serological reactions of nonleprous groups from July 1, 1954 to June 30, 1957.*

Groups	Total specimens	Kahn		VDRL		Kolmer	
		Total reactors	Per cent	Total reactors	Per cent	Total reactors	Per cent
Blood Plasma Dehydrating Lab.	8145	577	7.08	200	2.45	235	2.88
Cavite Social Hygiene Clinic	3241	507	15.64	421	12.98	444	13.69
Nat. Penitentiary	548	74	13.50	51	9.30	54	9.85

[3] Intern. Journ. Lepr. (4) **25** (1957).
[4] Amer. Journ. Trop. Med. **4** (1955) 41–46.

Table 6 shows the seroactivities to VDRL and Kolmer tests are much lower than for Kahn test, the degree of seroreactivity depending on the group examined.

In the tuberculoid group two patients were examined twice with time intervals varying from three months to 1½ years. In each case the first examination was nonreactive to all the serological tests, but the second examination reactive to either two or three tests. It would be interesting if we can actually determine what in the disease is responsible for the increased reactivity to Kahn test as it is very apparent from our results that the type of leprosy has a relation to seroreactivity.

Kvittengen, et al.[5] made an observation that the Kahn test among those with lepra reaction is usually positive and that results of serological reactions are affected by aggravation of the disease. This has also been brought out by our study.

Kvittengen[6] mentioned of the probable correlation of hypercholesterolæmia and hypercalcæmia to seroreactivity. We hope we will be able to follow this up as well as the relation of serum albumin and globulin values and the course of the disease.

Most of the work of the authors reviewed did not give a significantly low VDRL seroreactivity. All are agreed that the lowest is with the Kolmer test. Still with the methods and antigens we used the seroreactivity of both tests in our hands are almost similar, significantly low, in both types of leprosy. We have found also that two out of three patients reactive to Kolmer in the lepromatous group admitted a suspicious VD exposure. For the detection of syphilis among lepers we recommend, therefore, the use of VDRL and Kolmer tests with the specific antigens we employed in this study. The Treponema Immobilization test would be better but this is not yet done here in the Philippines. Sera from five lepromatous patients were examined with the Treponema Immobilization test (TPI) and the Differential Slide Flocculation test (DSF), at the Division of Laboratories and Research, of the State of New York Department of Health, through the kindness of Dr. John F. Kent. Four of these sera were reactive to Kahn test with titers ranging from 8 to 64 dils. One was reactive to all three serologic tests. This same serum was positive to TPI and gave a typical syphilitic reactivity pattern to the differential slide flocculation test. One of the

[5] Bull. World Health Org. (4) 5 (1952) 481, 485, 494.
[6] Op. cit., 505–511.

sera reactive to Kahn was negative to TPI and gave a definite nonsyphilitic pattern to the DSF. The other three gave a nonspecific immobilization with TPI.

SUMMARY

Sera from 719 tuberculoid and 100 lepromatous cases of leprosy were tested for Kahn, VDRL and Kolmer tests with some modifications, especially in the antigens employed. Of the 719 tuberculoid cases 8.62 per cent reacted with Kahn, 3.19 per cent with VDRL, and 2.64 per cent Kolmer. Of the 100 lepromatous cases, 71 per cent reacted with Kahn, 6 per cent with VDRL, and 3 per cent with Kolmer. It was brought out that the types of leprosy affected the seroactivity to Kahn test. The lowest reactivity was for VDRL and Kolmer tests in both types and these two are recommended for use in the detection of syphilis among lepers.

ACKNOWLEDGMENT

I wish to express our gratitude to Dr. Walfrido de Leon, former director of the Bureau of Research and Laboratories, under whom this study was initiated; to Dr. T. P. Pesigan, present director, for his interest in this work; to the personnel of the Serology Unit for performing the actual tests; and to Dr. Jose Rodriguez, of the Bureau of Disease Control and his staff in the Division of Sanitaria, especially to Dr. Perpetua Reyes-Javier, for the help they have extended.

STUDIES ON THE BIOLOGY OF PHILIPPINE MOSQUITOES, I

SOME BIONOMIC FEATURES OF ÆDES ÆGYPTI[1]

By AVELINO DEL ROSARIO
Bureau of Disease Control, Department of Health, Manila

The absence in Asia of yellow fever,[2] which is prevalent in Africa and Central and South America, is the main reason why the control of *A. ægypti,* the known vector of the disease, has received little attention despite its prevalence in many urban localities. In the Philippines, there has been practically no attempt[3] to control *A. ægypti,* although modern travel facilities here increase the risk of accidental introduction of the mosquito from other countries. Lately, however, considerable interest in this mosquito has been generated by the findings by Hammon, et al. (1956), that *A. ægypti* caught wild around Manila were positive for dengue virus types 3 and 4, the cause of the disease known as H-fever.

Much has already been published elsewhere about the biology of *A. ægypti.* Bacot (1917), Young (1922), Buxton and Hopkins (1927), and Roubaud (1927, 1929), as cited by Bonne-Wepster and Brug (1932), discussed extensively the factors which control egg-laying and hatching. Howlett (1913), Macfie (1916), Young (1922), and Hinman (1930), dealt with factors affecting larval development. Bonne-Wepster and Brug (1932) mentioned the works of many authors regarding the bionomics of its adults. Lately, Macdonald (1956) presented the larval and adult biology of *A. ægypti* in Malaya. Because in the Philippines there has been no investigation on the ecology of this species, this study has been made. All observations were carried out in the

[1] Assistance was received from Messrs. Nicanor Samson, Marciano B. Almeda, Jose G. Santos, Eliseo Enriquez, and Miss Juana Arenas, all of the Section of Entomology.

[2] Doctor Hammon explained the absence of yellow fever in the Philippines as due to cross-immunity among Filipinos; that is, immunity gained from infections by two or more types of group B viruses, resulting in immunity to any and all types of viruses of this group.

[3] Years ago control of *A. ægypti* and *A. albopictus* were undertaken in Manila by the City Health Department as part of the anti-mosquito nuisance campaign.

Institute of Malariology, Tala, Caloocan, Rizal, under ordinary room conditions. The mean monthly temperature ranged from 24° to 28°C; relative humidity, from 66 to 90 per cent.

THE COLONY

In order to facilitate our study, a laboratory colony was first established. Two house-caught gravid females from Makati and Marikina, Rizal Province, Luzon, formed the nucleus of our colony. Colonizing this species was quite easy as compared with our persistently frustrated attempts to colonize *minimus flavirostris*, the local malaria vector.

The rearing cage was approximately 15″ x 15″ x 20″, with two sides and the floor made of wood. Wire screen covered the other two sides and the top. To provide blood meal, a chicken immobilized at feeding time, was placed in the cage every day. In addition, the mosquitoes had free access to sugar solution in saturated cotton pellets. Oviposition jars consisted of petri dishes lined with water-saturated absorbent cotton topped with filter paper. Wet towels or cloth pieces were placed over the wire-screen top and sides of the cage to maintain humidity. At this writing, it is estimated that the colony has been maintained beyond the twelfth generation.[4]

EGG LAYING

Oviposition occurred mostly at night, although some batches were also laid during the day. The adults laid eggs readily on damp filter paper, but they oviposited just as well in open dishes with water. Concentration of eggs was noted along the ridges and border of damp filter paper substrates, while in open dishes with water the eggs were accumulated along the sides just above the water level. Not infrequently eggs were laid on the cotton pellets with sugar solution.

To determine oviposition-site preference in the laboratory, twenty-five gravid females were isolated in a 1′ x 1′ x 1′ cage. Two petri dishes with water-saturated cotton lining and covered with filter paper, and another two, with just plain water, were placed inside the cage. In another cage, a similar number of gravid females was placed, but for oviposition requirements,

[4] A large number of eggs from this colony was air-shipped to Dr. Cornelius B. Philip of the Rocky Mountain Laboratory, Montana, U.S.A., who has raised a colony there for testing Philippine *ægypti* in yellow fever infections.

two dishes with white, damp filter paper, and another two, with black, damp filter paper, as substrates, were provided. The results of six replicates after three days are shown in Table 1.

TABLE 1.—*Oviposition preference of A. ægypti in the laboratory.*

Test no.	No. of mosquitoes	No. of eggs laid		Test no.	No. of mosquitoes	No. of eggs laid	
		Damp filter	Open water			White filter	Black filter
I	25	458	1,269	I	25	121	966
II	25	568	364	II	25	242	694
III	25	476	715	III	25	197	572
IV	25	771	389	IV	25	168	536
V	25	660	312	V	25	210	587
VI	25	695	665	VI	25	158	660

The foregoing table shows that in four out of six tests, damp filter paper was selected, while a black substrate was very much more preferred to a white one.

LARVAL AND PUPAL DEVELOPMENT

The larvæ were reared in white enamelled pans containing a two-inch depth of tap water with chicken laying mash as food. In more than 200 individual isolations, the larval stage varied from 5 to 10 days; average 6.2 days. In nine cases, however, prolonged larval stages were noted (12 to 22 days). The duration of the pupal stage varied from 1.5 days to 4 days; average 2.2 days.

FIRST BLOOD MEAL AFTER EMERGENCE

In general, mosquitoes do not feed within 24 hours after emergence, because their mouth parts are still too tender to penetrate the skin. To find out the time of first feeding of Philippine *ægypti*, three tests involving 400 adults were carried out.

TABLE 2.—*First blood meal after emergence.*

Test no.	No. of mosquitoes	Time of feeding after emergence									
		First day		Second day		Third day		Fourth day		Fifth day	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
I	76	18		45		7		5		1	
II	171	17		87		62		5		0	
III	153	7		92		53		1		0	
Total	400	42	10.5	244	56.0	122	30.5	11	2.75	1	0.25

Females which had emerged twenty-four hours previously were offered human blood meal and those which refused to feed the first day were again given another chance the next day and so on until all had fed. The results are shown in Table 2.

It is evident from the foregoing data, that Philippine *ægypti* mostly takes its first blood meal two to three days after emergence.

FEEDING AND MATING HABITS

The adults in the rearing cage bit readily during the day as well as during the night. During the course of this study, it was not infrequent that some adults escaped from the colony cages or from the breeding pans, especially when there was not enough time to pick all the pupæ and the adults emerging therefrom. These escaped adults were very annoying the whole day, pestering, biting, hovering, and sometimes buzzing around the head. Co-workers in the adjacent building about five meters away complained of their vicious attacks. Casual callers in the insectary seldom escape their aggressiveness.

In order to determine the day or night difference in biting rate, two groups of 72-hour-old females (100 in each group) were isolated in a 1′ x 1′ x 1′ group cage. One group was allowed to feed on human from 3:00 to 3:30 p.m., while the other group from 8:00 to 8:30 p.m. (under complete darkness). The results of two replicates showed that 87.5 per cent fed during the day and 73.5 per cent during the night.

It has been observed that as a source of meal, human blood was preferred to chicken. As previously mentioned, a chicken was kept in the colony cage during the day. However, each time the chicken was removed, and the arm of the author placed inside the cage, a great number would attack it instantly. A number of adults would also bite the hand during the process of putting and removing the chicken and the oviposition dishes. At one time, a small number of 48-hour-old females was allowed to take the first blood meal in a cage with a chicken and a human arm together. Close observation, without confirmation with precipitin tests, showed eighty per cent fed on the human arm.

A. ægypti mated readily in the colony cage during daylight hours. Isolated males and females in small lamp chimneys were also frequently seen in the act of mating. Escaped adults were quite often noted in the act of pairing. Mating in the cage seemed to take place invariably following any disturbance which

caused their flight. Copulation seemed to be consummated either while in flight or resting on the wall of the cage, where usually they landed in a face to face position with their genitalia engaged.

FEEDING AND OVIPOSITION CYCLES

In this observation, 100 females were used. Each female was placed with a male in a small lamp chimney approximately three inches high and one inch in diameter. One end was covered with fine bobbinet and the other end with filter paper. The lamp chimneys were then set on a pan, the bottom of which was lined with a double layer of wet filter paper. They were offered blood meals each day for 15 minutes and in addition they had access to sugar solution in cotton. Table 3 shows that following a blood meal, an average of 4.5 days elapsed before eggs were laid, and the females fed again 2.5 days following oviposition. The average interval between blood meals was 3.4 days.

TABLE 3.—*Feeding and oviposition cycles of A. ægypti in the laboratory.*

No. of females	Blood meal no.	Oviposition no.	Days	No. of females	Oviposition no.	Blood meal no.	Days
100	I	I	5.5	20	I	II	1.6
15	II	II	4.4	4	II	III	2.0
3	III	III	4.0	1	III	IV	4.0
1	IV	IV	4.0	—	—	—	—
Average			4.5				2.5

NUMBER OF EGGS/BLOOD MEAL/FEMALE

Apparently the number of eggs varies with the kind of blood meal ingested. Mathis (1934), cited by Macdonald (1956), found that 25 per cent more eggs were laid by human-fed than those fed on animals. Woke (1937), however, found that mosquitoes which fed on man and rhesus monkeys produced a similar number of eggs per milligram of blood ingested, but the number was significantly lower than those produced by mosquitoes that fed on rabbit, guinea pig, canary, turtle, or frog. In our observation, however, significantly more eggs were laid by chicken-fed adults than those fed on human, as shown in Table 4.

TABLE 4.—*Comparative number of eggs laid by human- and chicken-fed A. ægypti.*

Number of mosquitoes	Human-fed		Chicken-fed	
	No. of eggs	Average	No. of eggs	Average
100	5,698	57	7,564	76

In connection with the human-fed mosquitoes, 66 laid eggs after one blood meal, 20 after two, 9 after three, 4 after four, and 1 after eight blood meals. However, there seemed to be no direct relationship between the number of blood meals taken and the number of eggs produced:

No. of eggs after single blood meals (66 females)	3,899
Average per female	59
No. of eggs after multiple blood meals (34 females)	1,799
Average per female	53

Eighty-five per cent of the foregoing females laid eggs only once, while 15 per cent laid from 2 to 4 times. The minimum number of eggs laid was 15, the maximum 140. The number of eggs laid per blood meal and per female are shown in Table 5.

TABLE 5.—*Number of egg/blood meal/female of A. ægypti (human-fed).*

Number of eggs/blood meal		Number of eggs/female	
No. of females	No. of eggs	No. of females	No. of eggs
4	15—19	34	less than 50
10	20—29	51	50—100
14	30—39	10	101—150
14	40—49	5	151—200
10	50—59	—	—
13	60—69	—	—
16	70—79	—	—
10	80—89	—	—
6	90—99	—	—
2	100—109	—	—
1	140	—	—

At one time during the course of this study, about a hundred eggs were laid autogenously, 68 of which hatched but only 62 emerged into adults. However, when later fed on sugar alone, they did not lay eggs. It was further observed that virgin females laid eggs which did not hatch.

LONGEVITY

One of the factors that determines whether a given species will be a vector is its longevity in nature. For a species to be an efficient vector of filariasis, dengue, or viral disease, a considerable number of individuals should live more than 12 days. No local information appears to be available concerning the longevity of *A. ægypti.* To supply this need, 250 females and 225 males were used in this observation. They were placed in two 1′ x 1′ x 1′ cages and offered human blood meal everyday. In addition, sugar solution in cotton was made available at all

times as a supplementary food. To provide adequate humidity, wet towels were maintained over the cages. The number of deaths were then recorded daily. The results are shown in Table 6.

TABLE 6.—*Longevity of A. ægypti in the laboratory.*

Longevity in days	No. females	Per cent	No. males	Per cent
1–5 6–10 11–15	16 32 16	25.6	61 92 51	90.7
16–20 21–25 26–30	18 17 12	18.8	11 7 1	8.4
31–35 36–40 41–45	10 14 17	16.4	— 1 —	0.4
46–50 51–55 56–60	25 10 12	18.8	— — —	—
61–65 66–70 71–75	11 3 15	11.6	1 — —	0.4
76–80 81–85 86–90	10 5 2	6.8	— — —	—
91–95 96–100	2 3	2.0	— —	—
Total	250	—	225	—

An analysis of the foregoing table shows that 74 per cent of the females lived from 15 to 97 days, or more, which was sufficiently long for transmission of filariasis, dengue, or viral disease. The males, however, were short-lived, 91 per cent surviving up to two weeks only. The maximum survival of the females was 97 days; 65 days for the males.

SEX RATIO

In more than 50 individual batches of eggs used in this observation, there was apparently no significant difference between the number of males and females which emerged. However, the males were observed to emerge first.

VIABILITY OF EGGS

Newly laid eggs on damp filter paper submerged directly in

water began to hatch in three days, but mostly from five to ten days. However, if they are first stored for two to seven days in tightly stoppered bottles to allow development of the embryo, a rapid and more complete hatching took place. Eggs submerged directly in water produced 59 per cent viability (1142/1926); those stored for one day, 74 per cent (475/642); while those stored from two to seven days, 83 to 91 per cent (660 to 2153 eggs). Storage for 15 days was tried and 72 per cent hatched (228/316).

Eggs when stored from two to seven days could withstand desiccation at room temperature for 42 days or longer. In one observation, eggs stored for seven days and dried for two months remained 79 per cent viable (498/628).

No. of days dried		Viability *Per cent*
1–3	—	67–90
4–5	—	40–45
6–7	—	33–38
8	—	28
14	—	16.55

The above-mentioned rates were the results of a week-long observation from the time the eggs were submerged. Likewise, the eggs of *A. ægypti* could withstand long period of refrigeration. Newly laid eggs stored in a kerosene refrigerator for one month produced 54 per cent viability (81/150); while in two tests on eggs matured for four days, about 70 per cent still hatched out after two months under the same conditions, *vide* data below:

Test No.	No. of eggs		No. hatched		Viability
I	258	—	174	—	67
II	334	—	233	—	70

SURVIVAL OF LARVÆ AND PUPÆ UNDER EXPERIMENTAL DROUGHT CONDITIONS

This observation was made to determine the effect of artificial drought conditions on the survival of the larvæ and pupæ. The tests were performed in Petri dishes using twenty larvæ or pupæ per test. Petri dishes were covered with a disc of filter paper cut to cover bottom and sides. The larvæ or pupæ were then pipetted into the paper, care being taken to avoid inclusion of too much water. The dishes were turned upside down and the disc manipulated so as to drain off excess water. The dishes were finally covered and examined after 1, 2, 3, and 4 days

of exposure. The number of deaths in each case was noted. The survivors were then placed in water, fed, and observed to emergence.

The results are summarized in Table 7. The first- and second-instar larvæ were mostly killed by two to three days exposure; a few survived up to four days. However, not one emerged to the adult stage. The third and fourth instars were more resistant to drying. A fairly large number survived after four days of exposure, and some were able to emerge into adult. The pupæ proved highly resistant. Exposed for one to two days, the majority still produced apparently normal adults.

TABLE 7.—*Mortality of larvæ and pupæ exposed to artificial drought.*

Larval instars	Days exposed	No. of larvæ	Mortality	Pupated	Emerged
			Per cent	*Per cent*	*Per cent*
I to II	0	60	5.0	93.3	91.7
	1	120	45.0	26.7	26.7
	2	120	72.5	20.0	20.0
	3	120	86.7	6.7	6.7
	4	120	98.3	0.0	0.0
III to IV	0	60	3.3	96.7	96.7
	1	120	17.5	61.7	60.8
	2	120	48.3	35.0	32.5
	3	120	65.8	19.2	19.2
	4	120	75.8	4.2	3.3
Pupæ	0	60	0.0	—	100.0
	1	60	11.7	—	80.0
	2	60	6.7	—	93.3

SUMMARY AND CONCLUSIONS

1. A colony of *Ædes ægypti* was established and maintained to facilitate studies on the various aspects of its biology in the laboratory.

2. Under ordinary room temperatures (24° to 28°C) development of *Ædes ægypti* from eggs to adult was completed in two weeks, more or less.

3. The first blood meal was taken two or three days after emergence, followed by oviposition in four or five days; the female fed again two or three days later.

4. Individual female fed as many as eight times during her lifetime in the laboratory. The average interval between blood meals was 3.4 days. Usually after one blood meal, eggs were laid, but there were several instances which required multiple blood meals before eggs were deposited.

5. The minimum number of eggs per human blood meal was 15, the maximum 140; average 57. The number of eggs laid by chicken-fed adults was significantly higher than those of the human-fed ones (minimum 27, maximum 116, average 76). Apparently, the number of eggs varies with the kind of blood meal ingested.

6. The viability of stored and unstored eggs was presented. It was shown that storage in tightly stoppered bottles considerably increased viability as well as resistance to desiccation.

7. The larvæ were able to survive four days of experimental drying and developed into apparently normal adults; the pupæ, too, were highly resistant as almost all that had been desiccated for one or two days developed into adults.

8. In the laboratory, the females fed readily either by day or by night. Man was preferred to chicken as a source of blood meal. However, it seems probable that it will feed on any animal if necessary.

9. The majority of the experimental adults lived more than 15 to 97 days. In the natural environment their life is probably shorter, because of adverse weather conditions and natural enemies. However, it seems reasonable to assume that their average life span is about 30 days, fully sufficient for developing and transmitting filariasis, dengue, or viral disease, of which this species may be a potential or actual vector.

In summary, these studies showed that *Ædes ægypti* possesses the potentialities of a dangerous vector. Its reproductive potential is quite high, and it can survive untoward conditions which would be fatal to many other mosquito species. It has a high predilection for man's blood and a large proportion can live long enough to permit the disease organism to develop to the infective stage. Furthermore, a high proportion of the females feed more than once in the course of one gonotrophic cycle, thus enhancing its capacity to transmit disease.

REFERENCES

1. BONNE-WEPSTER, J., and S. L. BRUG. The subgenus Stegomyia in Netherlands India. Bijblad **2** (1932) 47–72.
2. HAMMON, W. MCD., et al. Studies on Philippine hemorrhagic fever: Relationship to dengue virus. Mimeographed Report (1956) 3 pp.
3. HAMMON, W. MCD., et al. Lecture given at Plasma Building, Manila, September 30, 1958.
4. MACDONALD, W. W. Ædes ægypti in Malaya, II. Larval and adult biology. Ann. Trop. Med. Parasit. (4) **50** (1956) 399–414.

BEHAVIOR PATTERN OF ADULTS OF ANOPHELES MINIMUS FLAVIROSTRIS LUDLOW

C. M. URBINO, F. DIGMA, and B. ABINOJA
Bureau of Disease Control, Department of Health, Manila

The meager observations extant before 1953 in the Philippines on the malaria-mosquito bionomics in human dwellings (2–5) were too inadequate to provide a satisfactory basis for practical application of recently developed residual spraying of human dwellings. Studies, therefore, had to be made at the same time that the DDT Pilot Project in Mindoro was being developed.

The object of the present paper is to present the results of studies on the behavior pattern of the malaria vector in Philippine human dwellings as a suitable guide for residual spraying under proper supervision.

The studies from which the paper is based were carried out at the Institute of Malariology (Malaria Field Center) at Tala, Caloocan, Rizal, from July, 1954, to October, 1956, and in Kidapawan and Malasila, northern Cotabato, from January, 1955, to January, 1956. No previous spraying of human dwellings had been undertaken in these areas.

MATERIALS AND METHODS

An observation house was built, 12′ by 12′ by 10′, with wooden walls, cogon roof, and provided with framed glass windows, 18″ by 24″, on all four corners of the house at the bottom of the walls, halfway to the top and at the head of the walls. The windows could be darkened when needed. A double door was provided to prevent mosquitoes from escaping. A one-inch slit opening, ten ft. long, pointing towards the inside the observation house connected it to the animal-baited trap. Blooded mosquitoes escaped through the slit openings into the observation house. Mosquito collections were made at different times of the day after mosquitoes were allowed to settle normally. When a mosquito was spotted with a flashlight, the light intensity in candle power, the distance, and direction from the light openings were determined by a light meter and foot rule; after which the mosquito was collected and identified. The catches were arranged according to location with respect to

light candle power and height of rest in feet. Only *Anopheles minimus flavirostris*, the principal malaria vector, is considered in this report.

Daylight catches were conducted in Kidapawan, Cotabato, from human dwellings in relation to light, height, man and other objects. Outside wall catches during the day were likewise made; the type of the area is distinct from that of western Luzon.

RESULTS AND DISCUSSIONS

Influence of light on daytime resting behaviour.—*Anopheles minimus flavirostris* prefers light varying in intensity from 0 to 5 candle power to the extent of from 93.15 per cent to 100 per cent, although adults have also been observed at light from 6 to 25 light candle power. A single mosquito observed from 51 to 56 candle power was obviously seeking to escape. The summarized results of three sets of data are shown in Table 1. It is, therefore, evident that residual spraying must be applied to all the dark corners and as high as ten feet.

TABLE 1.—*Height of resting places of A. minimus flavirostris in relation to light intensity. (July 1954 to October 1956.)*

Light candle power	Height of rest in feet											
	1	2	3	4	5	6	7	8	9	10	Total	Rate in per cent
0–5	67	47	37	40	28	26	10	7	3	2	267	98.16
6–10	0	0	0	1	0	0	0	0	0	0	1	0.37
11–15	0	0	0	0	0	0	0	0	0	0	0	0
16–20	0	1	0	0	0	0	0	0	0	0	1	0.37
21–25	1	0	0	0	0	0	1	0	0	0	2	0.78
26–30	0	0	0	0	0	0	0	0	0	0	0	0
31–35	0	0	0	0	0	0	0	0	0	0	0	0
36–40	0	0	0	0	0	0	0	0	0	0	0	0
41–45	0	0	0	0	0	0	0	0	0	0	0	0
46–50	0	0	0	0	0	0	0	0	0	0	0	0
51–55	0	1	0	0	0	0	0	0	0	0	1	0.37
TOTAL	68	49	37	41	28	26	11	7	3	2	272	
Per cent	25.0	18.01	13.60	15.07	10.29	9.56	4.05	2.58	1.10	0.74		100.0

Height of mosquito resting place at daytime.—Of 73 *A. minimus flavirostris* adults caught in 1954, 84.93 per cent rested within man's reach, at 7 feet. In 1955, 99.3 per cent of 143 adult *A. minimus flavirostris* rested along the walls within man's reach of 7 feet. In 1956, all of 56 *A. minimus flavirostris* adults observed alighted within 6 feet from the floor. The tendency to alight is strong within the height of man's reach.

It is interesting to note, after a correlation of the figures from 1954 to 1956 in summary Table 1, that 43.01 per cent of the mosquitoes alighted opposite the exposed feet of man; 28.67 per cent against exposed arms, and 19.85 per cent against the face. It is further shown that 98.16 per cent of the total *A. minimus flavirostris* adults caught from July, 1954, to October, 1956, alighted at light intensities from 0 to 5 light candle power. Only 1.84 per cent alighted at light intensities above 5 light candle power. It is evident that *A. minimus flavirostris,* under conditions existing at Tala, Caloocan, Rizal, prefers dark corners of the observation house at heights within the reach of exposed parts of the human body.

Day catches in human dwellings in Kidapawan, Cotabato.—Daytime catches of *A. minimus flavirostris* (Table 2) showed that the adults were alighting not very far from the light openings of houses, such as windows. Of the 446 adult mosquitoes inside the house, 94.62 per cent alighted within 8 feet of the windows where the people sit and laze after dinner. Ninety-seven and fifty-three hundredth per cent (93.53) alighted below

TABLE 2.—*Direction and distance of resting places of A. minimus flavirostris in relation to the windows and doors in Kidapawan, Cotabato. (January 1955 to January 1956.)*

Distance in feet from light opening	Light opening direction in o'clock												Total	Per cent
	1	2	3	4	5	6	7	8	9	10	11	12		
1	2	2	4	7	7	11	17	8	4	0	3	0	65	14.57
2	0	0	3	2	13	13	12	3	2	0	1	0	49	10.99
3	0	3	6	4	24	24	17	4	6	0	0	0	88	19.73
4	0	2	4	2	17	11	22	1	7	2	0	0	68	15.25
5	1	1	2	6	5	7	9	4	3	0	0	0	38	8.52
6	0	0	8	5	4	9	21	4	5	1	0	0	57	12.78
7	2	0	0	3	8	7	6	1	2	2	1	0	32	7.17
8	0	1	0	0	4	10	5	4	0	1	0	0	25	5.61
9	0	0	0	0	0	1	1	1	0	0	0	0	3	0.67
10	2	0	0	0	2	0	5	0	0	0	0	0	9	2.02
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	3	0	1	1	1	0	0	0	6	1.35
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	1	0	0	0	1	0	0	0	0	0	0	0	2	0.45
15	1	0	0	0	2	0	0	1	0	0	0	0	4	0.89
Total	9	9	27	29	90	93	116	32	30	6	5	0	446	
Per cent	2.02	2.02	6.05	6.50	20.18	20.85	26.01	7.17	6.73	1.35	1.12	0		100.0

the level of 9:00 to 3:00 o'clock through the center of the window. Sixty-seven and four hundredth per cent alighted from

5 to 7 feet from the windows, which represent the corners of most dwellings in small areas.

Including 16 adults or 3.46 per cent recovered from the outer surface of the house walls from under dried nipa leaves used for walling, the 462 adult catches were distributed (Table 3) as follows:

TABLE 3.—*Height from floor where A. minimus alight in the human dwellings and fixtures.*

House parts and fixtures in and about the house	Height from floor in feet								Total	
	1	2	3	4	5	6	7	3	Number	Per cent
Bamboo walls	96	21	16	7	3	1	0	0	144	31.17
Wooden walls	150	20	16	8	5	0	0	0	199	43.07
Box	1	0	0	3	0	0	0	0	4	0.87
Abaca stripping machine	19	3	2	0	0	0	0	0	24	5.19
Can	19	2	0	2	0	0	0	0	23	4.98
Hen's nest	0	3	2	6	2	2	0	0	15	3.25
Stone	2	0	0	0	0	0	0	0	2	0.43
Cement wall	2	0	0	0	0	0	0	0	2	0.43
Iron saw	1	0	0	0	0	0	0	0	1	0.22
Coconut husk	1	0	0	0	0	0	0	0	1	0.22
Iron plow	2	0	0	0	0	0	0	0	2	0.43
GI sheet	1	1	0	0	0	0	0	0	2	0.43
Drum	2	2	0	0	0	0	0	0	4	0.87
Bamboo pile	0	1	0	0	0	0	0	0	1	0.22
Stone or gravel	1	0	0	0	0	0	0	0	1	0.22
Basket	6	3	0	0	0	1	0	0	10	2.16
Pandan	2	0	0	0	0	0	0	0	2	0.43
Sewing machine	1	0	0	0	0	0	0	0	1	0.22
Palay	1	0	0	0	0	0	0	0	1	0.22
Sawali	2	0	0	0	0	0	0	0	2	0.43
Abaca	1	0	3	1	0	0	0	0	5	1.08
Outside wall	2	6	6	2	0	0	0	0	16	3.46
TOTAL	312	62	45	29	10	4	0	0	462	
Per cent	67.53	13.42	9.74	6.28	2.16	0.87	0	0		100.00

Bamboo walls 31.17 per cent; wooden walls 43.07 per cent; underneath leaves of nipa shingles outside walls 3.46 per cent; 22.3 per cent in the dark corners of abaca stripping machine under the house, in tin cans inside the house, hen's nest, old baskets in house corners, stones or gravel under the house, under shades of abaca bales, empty drums, empty boxes, cement walls, coconut husks piled for fuel, bamboo piles, pandan plant in the windows, sewing machine, sacks of palay and sawali under the house, in the order of their importance.

The adults recovered at 1 foot above the ground or floor were 67.53 per cent; at 2 feet, 13.42 per cent; at 3 feet, 9.74 per cent; at 4 feet, 6.28 per cent; at 5 feet, 2.16 per cent; and at 6 feet,

0.87 per cent. Incidentally, the results of Baisas(1) a year before this observation was carried out in the same place gave 64.24 per cent *A. minimus flavirostris* resting at one foot.

It is thus clearly shown that objects under the house, as well as parts of the house itself, must be sprayed. If objects under the house cannot be sprayed, they must be destroyed or stored away from the house.

OTHER OBSERVATIONS

Partial and irregular sequence of spraying individual houses and localities and lack of area coverage of all endemic areas have set back malaria eradication. These explain the high positivity rates and resumption of transmissions even in organized localities that have qualified for three to four years of consecutive residual spraying. Nothing short of complete spraying in all its aspects can hasten malaria eradication. Breaks through infections have been invariably associated with partial or unsprayed houses or communities.

It was earlier reported(6) that 43.04 per cent of *A. minimus flavirostris* adults caught at night were resting on the outside walls of human dwellings. The spraying(7) of the outside walls of the houses, in addition to the method now being practised in the Philippines, at the Tenth World Boy Scout Jamboree camp site in 1958, protected effectively about 15,000 temporary inhabitants in an otherwise malarious area from all biting insects. It is suggested therefore that spraying outside walls of the houses in malarious areas be practised. This will neutralize the nocturnal resting and the extra domiciliary biting habits of the most effective malaria vector in the Philippines to a great extent. Close supervision of the programs of the field operations adjusted to these observations is indispensable for best results.

SUMMARY

The behavior patterns of *A. minimus flavirostris*, the principal malaria vector in the Philippines, were observed from 1954 to 1956 at Tala, Caloocan, Rizal Province, and in human dwellings in Kidapawan and Malasila, Cotabato Province.

Mosquito collections were made after they had settled on the walls, and their distances from the floor and sources of light had been determined.

The tendency of the mosquitoes to alight witihn the height of a man's reach (7 feet) has been found to be strong. A higher percentage rests opposite the exposed human feet than opposite the exposed arms or face.

Mosquitoes prefer to rest in the darker corners of the house or within 8 feet of the windows where the human occupants usually sit after meals. They are also to be found on equipment, materials, and other objects in and under the house. Spraying should be done not only on interior walls but also on all objects under the house.

In the light of new findings about the resting places of the malaria vector, spraying should be extended to the outside walls of houses to make malaria eradication programs more effective under Philippine conditions.

REFERENCES

1. BAISAS, F. E. Notes on Philippine Mosquitoes, XVIII. Bull. Dept. Health **29** (1957) 68–89.
2. MANALANG, C. Notes on malaria transmission. Philip. Jour. Sci. **37** (1928) 123–131.
3. MANALANG, C. Malaria transmission in the Philippines, I. The natural vector. Philip. Jour. Sci. **45** (1931) 241–249.
4. URBINO, C. M. The density of Anopheles minimus var. flavirostris Ludl. by trapping with human baits and its relation with the factors that influence its variations. Monthly Bull. Bur. Health **16** (1936) 471–492.
5. URBINO, C. M. Malaria: Its problems and control in relation to the agricultural development of Oriental Mindoro. Proc. 5th Sci. Conv. February 21–26, 1939, in Nat. Res. Coun. Phil. Bull. **23** (1939) 129–130.
6. URBINO, C. M. Development of malaria control against A. minimus var. flavirostris Ludl. in the Philippines. Bull. Dept. Health (3) **31** (1959). In press.
7. URBINO, C. M. Preventive Measures Against Diseases at the Tenth World Boy Scout Jamboree **31** (1959) 22–39.

THE PHILIPPINE SPECIES OF CHRIODES (OPHIONINÆ, ICHNEUMONIDÆ, HYMENOPTERA)

By Clare R. Baltazar
Bureau of Plant Industry, Manila

SIX TEXT FIGURES

The genus *Chriodes* is common in the Old World Tropics. Several species of *Chriodes* from the Philippines, Ceylon, Java and Madagascar were described under different generic names but these have been synonymized by Townes in Proc. Ent. Soc. Washington **59** (1957) 103. Other specimens of *Chriodes* examined came from India, Thailand, S. China, Sumatra and Formosa.

There are eight species of *Chriodes* described in this paper, seven considered new. This study was based on loan materials from the United States National Museum, Washington, D. C., and Townes' collection, Museum of Zoology, University of Michigan, Ann Arbor; the collection of the Bureau of Plant Industry, Manila; and a few specimens borrowed from the University of the Philippines, College of Agriculture, Los Baños; and the Chicago Natural History Museum, Chicago.

Genus CHRIODES Fœrster

Head lenticular from lateral view; temple very narrow, sometimes receding; malar space absent; eyes extremely large, strongly convergent, hairy or bare; face subtriangular, distinctly separate from the clypeus by a broad transverse groove, not a suture; frons polished, bare, with a median sulcus; vertex abruptly receding to occiput; occipital carina present but not prominent.

Mesoscutum usually polished, sometimes mat; notaulus shallow or impressed to about 0.7 the length of mesoscutum; sternaulus deeply impressed over the entire length of mesopleurum or only its anterior 0.3; prepectus present; mesopleurum with few or numerous punctures; metapleurum punctate; scutellum subtriangular, carinate, or not carinate at side; propodeum with distinct carinæ, its spiracle situated on anterior 0.4, apical area transversely wrinkled; mesosternal carina in front of middle coxæ entire; areolet absent or open; nervulus interstitial with basal nervure; nervellus broken or entire; fore and middle tibiæ slightly incrassate; claws simple.

First tergite elongate and narrow, about 6 times as long as basal width, its spiracle situated at the middle or posterior 0.4, postpetiole swollen; tergite 3 to 7 strongly compressed, moderately pubescent; ovipositor notched near the apex (Fig. 6).

In the Philippines, all are small (7 to 12 mm long), black species with the antennæ banded with white at or beyond the middle in the female but entirely black in the male. The third and fourth tergites in some species are marked with fulvous, and the legs are ferrugineous or black.

Specimens were collected mostly in mountain areas. *Chriodes minutus* (Ashmead) was caught in both lowland and highland.

The anomalous structure of the species in the genus has made its classification difficult. Ashmead placed specimens of the same species in three different tribes: in *Atrometus* (Therionini) in 1904, in *Chriodes* (Hemitelini) in 1905, in *Nesomesochorus*, erecting a new tribe, Nesomesochorini, also in 1905.

Betrem (1932) excluded *Klutiana* from the Ophioninæ because he believed it lacked the subapical notch on the ovipositor; however, this notch is present. He found similarities in *Thymaris* (Tryphoninæ) but mentioned equally significant differences. He concluded that the genus must be nearest Hemitelini.

Seyrig (1935) erected his tribe Mavandini for the genera *Mavandia* and *Mavandiella*, both synonyms of subgenera *Chriodes* and *Klutiana*, respectively. Townes (1957) stated that *Chriodes* and the Neotropic genus *Nonnus* constitute a distinct section of the tribe Porizonini, Ophioninæ.

Key to the species of Philippine Chriodes

1. Nervellus broken or discoidella present (Fig. 1); scutellum carinate at side; second abscissa of discoideus usually subequal to or longer than third abscissa; sternaulus usually weak, not sharp beyond midlength of pleurum .... Subgenus *Chriodes*, 2

   Nervellus not broken or discoidella absent (Figs. 3 and 6); scutellum not carinate at side; second abscissa of discoideus absent or shorter than third abscissa; sternaulus usually sharp over the entire length of pleurum .... Subgenus *Klutiana*, 3

2. Sulcus present between eye and posterior ocellus; occipital carina obsolescent ventrally; first tergite without glymma; eye bare; face below 2.0 to 2.5 times (in male and female) the subapical width of mandible. .... *sulcatus* sp. nov.

   Sulcus absent between eye and posterior ocellus; occipital carina entire; first tergite with glymma; eye hairy in female; face below 1.5 to 2.0 (in male) or 0.7 to 1.0 (in female) times the subapical width of mandible .... *minutus* Ashmead

3. Sternaulus short, about 0.3 the length of mesopleurum; mesoscutum, ventral half of mesopleurum, sternum and propodeum microreticulate; first tergite with glymma .... *reticulatus* sp. nov.
   Sternaulus impressed beyond half or on the entire length of mesopleurum; mesoscutum polished, ventral half of mesopleurum and sternum punctate or rugoso-punctate, propodeum usually polished; first tergite with or without glymma 4
4. Intercubitus and second section of cubital vein meeting at about a 60° angle (Fig. 3); basal half of second tergite mat; ovipositor 1.6 to 1.9 times as long as the hind tibia 5
   Intercubitus and second section of cubital vein meeting at about a 90° angle (Fig. 6); basal half of second tergite polished or subpolished or mat; ovipositor 1.0 to 1.2 times as long as the hind tibia 6
5. Hind coxa and tibia largely black; face below 1.2 to 1.5 (in male) or 0.7 to 1.0 (in female) as wide as subapical width of mandible; ovipositor fuscous to black, about 1.6 times as long as hind tibia. *baguionensis* sp. nov.
   Hind coxa and tibia largely ferrugineous to fuscous (darker in male); face below about 2.0 times (in male and female) as wide as subapical width of mandible; ovipositor yellowish brown to fuscous, about 1.9 times as long as hind tibia .... *insularis* sp. nov.
6. Nervellus slant or forming a 120° angle with submediella (Fig. 3); third tergite entirely black; face below 3.5 times (in male) or about 0.3 (in female) as wide as subapical width of mandible (Figs. 4 and 5); notaulus shallow and impressed on anterior 0.3 of mesoscutum .... *convexus* sp. nov.
   Nervellus vertical or forming a 90° angle with submediella (Fig. 6); third tergite usually fulvous on basal half; face below about 2.0 times (in male) or 1.0 (in female) as wide as subapical width of mandible; notaulus deep and impressed on anterior 0.6 of mesoscutum 7
7. Mesosternum and metapleurum with numerous coarse punctures; second tergite broad, about 2.25 times as long as apical width (in female); third tergite almost entirely fulvous; face below 1.5 times as wide as subapical width of mandible (in female, male unknown); ovipositor thick, about 1.2 times as long as hind tibia. *fulvipes* sp. nov.
   Mesosternum and metapleurum almost impunctate especially in the male or with very fine punctures; second tergite slender, at least 3.0 times as long as apical width (in female); third tergite dark or at most fulvous on basal half; face below 2.0 times (in male) or 1.0 (in female) as wide as subapical width of mandible; ovipositor slender 1.0 to 1.2 as long as hind tibia .... *townesi* sp. nov.

Subgenus CHRIODES Foerster

Chriodes FŒRSTER, Verh. naturh. Ver. Rheinlande **25** (1868) 178. No species. ASHMEAD, Proc. U. S. Nat. Mus. **28** (1905) 966. One species. Type: (*Chiodes*(!) *oculatus* Ashmead) = *Atrometus minutus* Ashmead (1904). Monobasic.

Nesomesochorus ASHMEAD, Proc. U. S. Nat. Mus. **28** (1905) 967. Type:

Nesomesochorus oculatus Ashmead. Monobasic.

Metanomalon MORLEY, Rev. Ichn. **2** (1913) 58. Type: *Metanomalon poliendum* Morley. Monobasic and original designation.

Mavandia SEYRIG, *In* Jeannel, R: Mission Scientifique de l'Omo. III (fasc. 18) (1935) 93–98. Type: *Mavandia nanyukiana* Seyrig. Original designation.

The subgenus *Chriodes* differs from *Klutiana* in having the discoidella vein. Other distinguishing characters are mentioned in the key.

CHRIODES (CHRIODES) MINUTUS (Ashmead). Figs. 1–2.

Atrometus minutus ASHMEAD, Proc. U. S. Nat. Mus. **28** (1904) 144. Type: Male, Manila (Washington, USNM 7921); ASHMEAD, Proc. U. S. Nat. Mus. **28** (1904) 156 (listed); BROWN, Philip. Jour. Sci. **1** (1906) 692. (listed); CUSHMAN, Arb. Morph. Tax. Ent. Berlin-Dahlem (4) **4** (1937) 300 (comb. nov., syn.) *Nesomesochorus;* TOWNES, Proc. Ent. Soc. Washington **59** (1957) 103, 113 (comb. nov., syn.) *Chriodes.*

Chiodes (sic!) oculatus ASHMEAD, Proc. U. S. Nat. Mus. **28** (1905) 966. Type: Male, Manila (Washington, USNM 8316). BROWN, Philip. Jour. Sci. **1** (1906) 692 (listed).

Nesomesochorus oculatus ASHMEAD, Proc. U. S. Nat. Mus. **28** (1905) 968. Type: Female, Manila (Washington, USNM 8337); BROWN, Philip. Jour. Sci. **1** (1906) 692 (listed).

Female.—Fore wing 3.0 to 6.0 mm long. Face below 0.7 to 1.0 as wide as subapical width of mandible; eye hairy; sulcus absent between eye and posterior ocellus; occipital carina entire. Mesoscutum smooth and shiny, sometimes microreticulate on middle lobe; notaulus impressed to about 0.7 the length of mesoscutum, meeting behind to form a U-shape; mesosternum and ventral half of mesopleurum closely punctate; metapleurum and anepimeron with finer punctures than on mesopleurum; sternaulus impressed on anterior 0.3 of mesopleurum. Intercubitus about 0.8 as long as second abscissa of cubital vein, these veins meeting at a 75° to 90° angle; nervellus broken at its ventral 0.3. First tergite with glymma; first sternite swollen at center; second tergite mat, coarser on basal half; ovipositor 1.0 to 1.1 as long as hind tibia.

Black with legs and one or two tergites fulvous. Scape and until the fifth flagellar segment fulvous; flagellar segments 10 to 13 or 11 to 13 white; fore and middle legs mostly fulvous except for fuscous tarsal segments; hind leg ferrugineous except for the dark coxa, second trochanter, ends of tibia and tarsus; basal 0.5 of first tergite, third and fourth tergites almost entirely or partly fulvous.

Male.—Fore wing 3.0 to 6.0 mm long. Differs from the female in the following: face below 1.5 to 2.0 times subapical width of mandible; eye not hairy; glymma on first tergite faint; basal 0.2 of second tergite fulvous; hind femur ferrugineous to fuscous; scape and until the third flagellar segment fulvous.

Specimens caught in the lowlands were smaller and tended to have lighter legs and more fulvous markings on the tergites than those caught in mountainous areas; also the punctures on mesosternum and ventral half of mesopleurum are coarser.

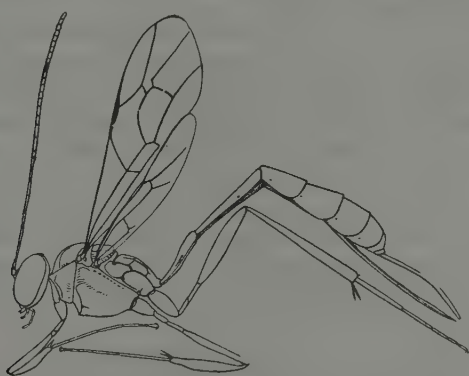


FIG. 1. *Chriodes* (*Chriodes*) *minutus* Ashmead, side view.

FIG. 2. *Chriodes* (*Chriodes*) *minutus* Ashmead, tip of ovipositor.

Specimens examined (115 males, 251 females) : female, Manila, W. A. Stanton (U. S. National Museum, paratype of *Atrometus minutus* Ashmead). From LUZON: near Baliwag, Abra; Cuenca and Mount Macolot, Batangas; Los Baños, Mount Banahao and Mount Maquiling, Laguna; Manila; Rosario, La Union; Baguio (5,000 feet), Banaue, Mount Data (7,800 feet, oak forest) and Mount Santo Tomas (6,500 feet), Mountain Province; Tagkawayan and Tiaong, Quezon. BOHOL: Biliran; Sierra Bullones (1,200 to 2,400 feet). MINDORO: Calapan (150 feet), Victoria and Mount Halcon (4,500 feet). NEGROS: Cuernos Mountains and Mount Canlaon (3,600 feet), Oriental Negros; Occidental Negros. SAMAR. MINDANAO: Butuan, Agusan; Basilan; Tangcolan, Bukidnon; Mount Apo (6,500 to 9,000 feet) and Mount McKinley (6,500 feet, mossy forest), Davao; Iligan and Kolambugan, Lanao; Surigao; Dapitan, Zamboanga.

Adults were caught throughout the year, from sea level to elevation as high as 9,000 feet. The only habitat records are from an oak forest in Mount Data and mossy forest in Mount McKinley. No host record of this species is available.

CHRIODES (CHRIODES) SULCATUS, sp. nov.

Female.—Fore wing 5.0 to 5.5 mm long. Face below 2.0 to 2.5 as wide as subapical width of mandible; eye hairy; sulcus present between eye and posterior ocellus; occipital carina obsolescent ventrally. Mesoscutum smooth and shiny, notaulus impressed to about 0.7 the length of mesoscutum; mesosternum closely punctate; ventral 0.5 mesopleurum rugoso-punctate; metapleurum, anepimeron and middle pleural area on propodeum punctate; sternaulus impressed on anterior 0.3 of mesopleurum; carina separating middle pleural area and lateral areas on propodeum obsolete. Intercubitus and second section of cubital vein subequal in length, these veins meeting at a 60° angle; brachiella long, about 0.8 as long as upper section of nervellus, subparallel to median; nervellus broken at its lower 0.3. First tergite without glymma; second tergite mat; ovipositor subequal in length to hind tibia.

Black with ferrugineous legs. Scape and until the third flagellar segment, mandible, third tergite and all legs ferrugineous except for fuscous second trochanters, apical ends of femora, both ends of tibiæ, and last tarsal segments; flagellar segments 12 to 16 white; tegula and ovipositor fuscous.

Male.—Fore wing about 5.0 mm long. Similar to the female except for coarser rugosity on the region of the sternaulus; carina present between middle pleural and lateral areas on propodeum; brachiella about 1.0 as long as upper section of nervellus.

Type.—Female, MINDANAO, Butuan, Agusan, Baker (U. S. National Museum); antenna incomplete.

Paratypes.—NEGROS: 2 females, Mount Canlaon, Oriental Negros, 3,600 feet, April 29 and May 1, 1953, H., M., and D. Townes (Townes coll.). MINDANAO: 4 males, 1 female, Butuan, Agusan; 2 females, Iligan, Lanao, C. F. Baker (U.S. National Museum and Bureau of Plant Industry, Manila); female, Mainit, Mount Apo, Davao, 4,300 feet, November 21, 1946, H. Hoogstraal; female, Baclayan, Mount Apo, Davao, 6,600 feet, November 11, 1946, H. Hoogstraal (Chicago Natural History Museum).

Subgenus KLUTIANA Betrem

Klutiana BETREM, Tijds. Ent. Suppl. **75** (1932) 89. Type: *Klutiana compressa* Betrem. Monobasic.

Mavandiella SEYRIG, *In* Jeanneal, R: Mission Scientifique de l'Om. III (fasc. 18) (1935) 93–98. Type: *Mavandiella hemitelina* Seyrig. Monobasic and original designation.

Klutiana may be differentiated from the subgenus *Chriodes* by the characters mentioned in the key. Townes (1957) stated that "*Klutiana* is a subgenus differing in the lack of the subdiscoidella vein."

CHRIODES (KLUTIANA) BAGUIONENSIS sp. nov.

Female.—Fore wing 3.0 to 4.0 mm long. Face below 0.7 to 1.0 as wide as subapical width of mandible; frons microreticulate; eye hairy. Mesoscutum shiny and somewhat microreticulate; notaulus extending to 0.7 the length of mesoscutum; sternaulus deeply impressed over the entire length of mesopleurum; side of pronotum with transverse wrinkles; mesosternum and mesopleurum finely punctate on ventral 0.5; metapleurum and spiracular area finely punctate. Intercubitus 1.0 to 1.3 times the second section of cubital vein, these veins meeting at about a 60° angle; first recurrent broken on its upper 0.3; brachiella very short. First tergite polished and finely reticulate, without glymma; second tergite entirely mat, 1.25 as long as the first; ovipositor about 1.6 as long as hind tibia.

Black with yellowish-brown legs. Flagellar segments 9 and 10, sometimes also 11, white; fore and middle legs almost entirely yellowish brown except for brown coxæ, in some, last tarsal segment and a subbasal band of middle tibia; hind leg fuscous or with lighter apex of femur and second trochanter, central 0.6 of tibia and spurs; axillaries and base of costa yellowish; ovipositor fuscous.

Male.—Fore wing 3.0 to 3.5 mm long. Similar to the female in color and sculpture except for the following: face below 1.2 to 1.5 as wide as subapical width of mandible; eyes not hairy.

Type.—Female, Mount Santo Tomas, Mountain Province, 6,500 feet, April 4, 1953, H., M., and D. Townes (Townes coll.).

Paratypes.—LUZON: 44 males, 10 females, the same locality as type, November 23 and December 28, 1952, April 3 and 4, June 20, November 23, 28, 29, December 28, 1953, H., M., and D. Townes; male, female, Mount Polis, Mountain Province, 5,500 feet, January 2, 1954, H., M., and D. Townes; female, Banaue, Mountain Province, 5,500 feet, December 29, 1953, H. M., and

D. Townes (Townes coll.); 43 males, 21 females, Baguio, Mountain Province, October 18 and 21, 1954, C. R. Baltazar; 8 males, female, Mount Santo Tomas, Mountain Province 6,500 feet, November 28 and 29, 1954, C. R. Baltazar and A. Marmeto (Bureau of Plant Industry, Manila); 31 males, 13 females, Baguio, Mountain Province, C. F. Baker (U. S. National Museum). MINDANAO: male, Dapitan, Zamboanga, C. F. Baker (U. S. National Museum).

CHRIODES (KLUTIANA) INSULARIS sp. nov. Fig. 3.

Female.—Fore wing 3.0 to 4.0 mm long. Very similar to *C. baguionensis* but may be distinguished from it basing on the characters pointed out in the key to species. Face below about 2.0 times as wide as subapical width of mandible, somewhat mat and finely punctate; eye not visibly hairy under 48x magnification, few short hairs visible under 64x magnification. Side of pronotum with few transverse wrinkles. First tergite with glymma; second tergite mat on basal 0.5; ovipositor 1.9 as long as hind tibia.

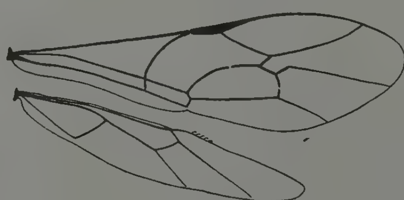


FIG. 3. *Chriodes (Klutiana) insularis* sp. nov., fore and hind wings.

Black with ferrugineous legs. Flagellar segments 9 to 11, axillaries and base of costa and apex of the seventh tergite white; legs mostly ferrugineous except for fuscous marks on front coxa and on hind leg—basal 0.3 of coxa, one or both trochanters, base of femur, and both ends of tibia; ovipositor yellowish brown.

Male.—Fore wing 3.0 to 3.5 mm long. Similar to the female in having the face below about 2.0 times as wide as subapical width of mandible. Hind leg darker than in female: hind femur and tarsi usually fuscous, sometimes ferrugineous.

The male is very similar in appearance to the male of *C. baguionensis* but may be distinguished by the slightly wider face below and the lighter legs of *C. insularis*.

Type.—Female, LUZON: Los Baños, Laguna, August 1, 1953, Townes family (Townes coll.).

Paratypes.—LUZON: 15 males, 8 females, Los Baños, Laguna, November 30, 1952, January 30, February 1, March 15, June 5, July 19, August 1, September 12 and 19, October 17, 1953; January 10, 1954, Townes family (Townes coll.); 2 males, female, Los Baños, Laguna, C. F. Baker; 29 males, 9 females, Mount Maquiling, Laguna, C. F. Baker (U. S. National Museum); female, Mount Maquiling, Laguna, February 8, 1951, L. B. Uichanco (College of Agriculture, Los Baños); male, 5 females, Mount Maquiling, Laguna, September 17, and 23, 1953, March 18 and November 12, 1954, March 17, 1960, C. R. Baltazar, R. Ballesteros and F. R. Candelaria (Bureau of Plant Industry, Manila); 4 males, Mount Banahao, Laguna, C. F. Baker; 2 females, Malinao, Tayabas, C. F. Baker (U. S. National Museum); 3 males, 4 females, Cuenca, Batangas, January 21, 26 and 29), February 11, 1954, C. R. Baltazar, A. Marmeto, E. Dagang and C. Macabasco (Bureau of Plant Industry, Manila); female, Mount Macolot, Batangas, October 24, 1953, H., M., and D. Townes; male, Balbalasang, Kalinga, Mountain Province, July 3, 1953, M. C. Townes (Townes coll.). PALAWAN: 3 males, Babuyan, Palawan, December 6, 1952, Henry Townes (Townes coll.). MINDORO: 3 males, 6 females, Alcate, Victoria, April 7 to 11, 1954, H., M., and D. Townes; 2 males, 2 females, Ilong, Mount Halcon, Oriental Mindoro, 4,500 feet, May 6 and 11, 1954, M. and D. Townes; female, San Luis, Calapan, 150 feet, May 17, 1954, H., M., and D. Townes (Townes coll.). Male, NW PANAY, C. F. Baker. 5 males, NEGROS: Cuernos Mountains, Negros Oriental, C. F. Baker (U. S. National Museum); male, female, Mount Canlaon, Oriental Negros, 3,600 feet, May 7, 1953, H., M., and D. Townes (Townes coll.); female, CEBU: Camp 7, Minglanilla, 5,000 feet, February 13, 1960, C. R. Baltazar. 3 males, 8 females, BOHOL: Sierra Bullones, 1,200 to 2,400 feet, April 16, to 26, 1955, C. R. Baltazar and M. Delfinado (Bureau of Plant Industry, Manila). Male, SAMAR: C. F. Baker (U. S. National Museum). MINDANAO: 3 males, Basilan, C. F. Baker; male, Dapitan, Zamboanga, C. F. Baker; female, Zamboanga, 1927, C. F. Baker (U. S. National Museum).

CHRIODES (KLUTIANA) RETICULATUS sp. nov.

Female.—Fore wing 3.0 to 4.0 mm long. Face strongly convergent below, 0.7 as wide as subapical width of mandible; eye

hairy; frons shiny and microreticulate. Mesoscutum, mesosternum, and ventral half of mesopleurum mat; notaulus extending to 0.7 the length of mesoscutum and meeting behind to form a U-shape; sternaulus short, impressed to anterior 0.3 of mesopleurum; propodeum and metapleurum finely reticulate; carina separating middle lateral and spiracular areas on propodeum obsolete. Intercubitus and second section of cubital vein subequal in length and meeting at a 75° to 80° angle. First tergite polished and with glymma; second tergite entirely mat; ovipositor about 1.3 as long as hind tibia.

Black with fulvous markings. Flagellar segments 9 to 11 white; fulvous on the following: scape, pedicel, flagellar segments 1 and 2, third tergite and almost all legs; brownish to fuscous at base of fore coxa, and on hind leg—coxa, second trochanter, femur, both ends of tibia and last tarsal segment.

Male.—Fore wing 3.0 to 3.5 mm long. Very similar to the female in color and sculpture. Differences are in the width of face below, that is, 1.5 times the subapical width of mandible; carina present between middle lateral and spiracular areas on propodeum.

Type.—Female, MINDORO: Mount Ilong, Oriental Mindoro, 4,500 feet, May 11, 1954, M. and D. Townes (Townes coll.).

Paratypes.—30 males, 4 females, same data as type, May 7 to 11, 1954 (Townes coll.; 4 males, 2 females, Bureau of Plant Industry, Manila); female, Mount Ilong, Oriental Mindoro, 2,600 feet, April 18, 1954, D. Townes (Townes coll.).

CHRIODES (KLUTIANA) CONVEXUS sp. nov. **Figs. 4 and 5.**

Female.—Fore wing 4.0 to 5.0 mm long. Face below about 0.3 as wide as subapical width of mandible; eye hairy, very strongly convergent below. Mesoscutum shiny or microreticulate; notaulus short, slightly impressed on anterior 0.3; prepectus, ventral 0.5 of mesopleurum and mesosternum, metapleurum and spiracular area closely punctate; carina separating median lateral and pleural areas on propodeum present but sometimes obsolete. Intercubitus and second section of cubital vein subequal in length and meeting at a 90° angle; first recurrent broken at upper 0.2; brachiella almost touching wing margin. First tergite polished and without glymma; second tergite subpolished on basal half and microreticulate on apical half; ovipositor 1.0 to 1.2 as long as hind tibia.

Black. Flagellar segments 10 to 11 or up to the 13th, axillaries and base of costa white; scape, pedicel, first trochanter of fore and middle legs, tibial spurs and ovipositor ferrugineous; subapex of ovipositor with a dark band.

Some specimens have the fore and middle legs almost entirely ferrugineous, hind leg fuscous with the first trochanter, central 0.7 of tibia, and tarsi yellowish brown.

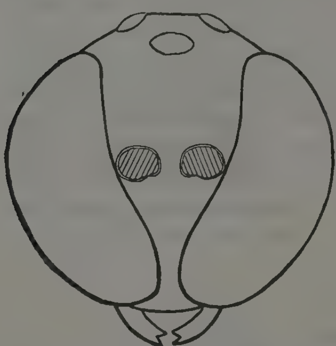


FIG. 4. *Chriodes* (*Klutiana*) *convexus* sp. nov., face of female.

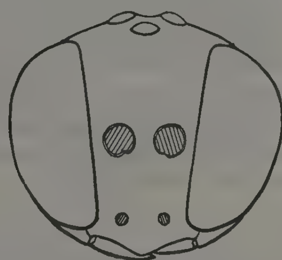


FIG. 5. *Chriodes* (*Klutiana*) *convexus* sp. nov., face of male.

Male.—Fore wing 3.5 to 4.0 mm long. Very similar to the female except for the wide face below, being 3.5 as wide as subapical width of mandible; clypeal foveæ deep; third tergite ferrugineous basally.

Type.—Female, BOHOL: Sierra Bullones, 1,200 feet, April 17, 1955, C. R. Baltazar (Bureau of Plant Industry, Manila).

Paratypes.—LUZON: Male, 2 females, Baguio Mountain Province, 5,000 feet, June 20 and 21, 1951, C. R. Baltazar (College of Agriculture, Los Baños); female, Mount Santo Tomas, Mountain Province, 7,200 feet, November 29, 1953, H. M., and D. Townes; 2 females, Mount Data, Mountain Province, 7,800 feet, December 31, 1952 and January 1, 1953, H. M., and D. Townes (Townes coll.); female, Mount Maquiling, Laguna, C. F. Baker (U.S. National Museum). BOHOL: Male, female, Sierra Bullones, 1,200 and 2,400 feet, April 21 and 26, 1955, C. R. Baltazar (Bureau of Plant Industry, Manila). Female, MINDORO: Alcate, Victoria, Oriental Mindoro, April 10, 1954, H., M., and D. Townes

(Townes coll.). MINDANAO: Female, Basilan, C. F. Baker (U.S. National Museum).

CHRIODES (KLUTIANA) TOWNESI sp. nov. Fig. 2.

Female.—Fore wing 3.0 to 3.6 mm long. Face below as wide as subapical width of mandible; eye hairy; temple about 0.25 times the depth of eye when measured at middle of eye; sulcus present between eye and lateral margin of posterior ocellus. Mesoscutum microreticulate, notaulus extending to 0.7 the length of mesoscutum; sternaulus shallow but impressed over the entire length of mesopleurum; mesosternum finely and scarcely punctate; mesopleurum and metapleurum shiny, a few punctures present on ventral half of mesopleurum. Intercubitus 0.8 as long as second section of cubital vein, these veins meeting at a 90° angle; nervellus not slanting, almost perpendicular to submediella. First tergite polished and without glymma; second tergite subpolished or inconspicuously mat; ovipositor 1.0 to 1.2 as long as hind tibia.

FIG. 6. *Chriodes (Klutiana) townesi* sp. nov., fore and hind wings.

Black with ferrugineous legs. Third tergite entirely black or fulvous on its basal half; scape, pedicel, flagellar segments 1 and 2, fore and middle legs except for dark tarsi, brownish yellow; front coxa fuscous in some specimens; hind leg mostly fuscous except for ferrugineous base of femur, central 0.6 of tibia, spurs and sometimes coxa and first trochanter.

Male.—Fore wing 2.5 to 3.0 mm long. Differs from female as follows: Face below 2.0 to 2.5 as wide as subapical width of mandible; eye not hairy or inconspicuous hairs under 64x magnification; clypeal foveæ distinct and near edge of eye; temple 0.3 to 0.4 times the depth of eye when measured at middle of eye; hind leg almost entirely fuscous except for ferrugineous central 0.6 of tibia.

Type.—Female, NEGROS: Mount Canlaon, Oriental Negros, 4,200 feet, May 1, 1953, H., M., and D. Townes (Townes coll.).

Paratypes.—LUZON: 5 males, female, Mount Maquiling, Laguna, C. F. Baker (U. S. National Museum; male, Bureau of Plant Industry, Manila), 2 males, Banaue, Mountain Province, December 30, 1953, and January 1, 1954, H., M., and D. Townes; female, Banaue, Mountain Province, 1955, W. Beyer (Townes coll.); female, Imugin, Nueva Vizcaya, C. F. Baker (U. S. National Museum). NEGROS: 3 males, 4 females, Mount Canlaon, Oriental Negros, 3,600 feet, April 29 to May 9, 1953, H. M., and D. Townes (Townes coll.; male, 2 females, Bureau of Plant Industry, Manila). MINDANAO: Female, Mount McKinley, Davao, 7,200 feet, September, 1946, H. Hoogstraal and F. G. Werner (Chicago Natural History Museum).

This species is named in honor of Dr. Henry K. Townes of the University of Michigan, Ann Arbor, Michigan.

CHRIODES (KLUTIANA) FULVIPES sp. nov.

Female.—Fore wing 4.0 mm long. Face below 1.5 times as wide as subapical width of mandible; eye hairy; temple about 0.2 the depth of eye when measured at middle of eye. Mesoscutum microreticulate, notaulus extending to 0.3 the length of mesoscutum; sternaulus extending over the entire length of mesopleurum; mesosternum and ventral half of mesopleurum coarsely punctate. Intercubitus 0.8 as long as second section of cubital vein, these veins meeting at a 90° angle; nervellus not slant, almost perpendicular to submediella. First tergite polished and without glymma; second tergite subpolished, 2.25 times as long as its apical width; ovipositor short and thick, about 1.2 times as long as hind tibia.

Black with ferrugineous fore and middle legs, hind leg dark: third tergite almost entirely fulvous except for black apical 0.2; scape and pedicel brownish yellow; flagellar segments 10 to 12 white; fore and middle legs fulvous except for dark ventral side of coxæ, hind leg fuscous but yellowish on apex of coxa, first trochanter, base of femur and tibia, somewhat ferrugineous on central 0.6 of tibia; ovipositor yellowish brown.

Male.—Unknown.

Type.—Female, LUZON: Mount Maquiling, Laguna, February 11, 1954, C. R. Baltazar (Bureau of Plant Industry, Manila).

NEW GENERIC SYNONYMS IN PARASITIC HYMENOPTERA

By Clare R. Baltazar
Bureau of Plant Industry, Manila

The present paper is the result of a study of some type specimens, mostly Oriental species, found in the U.S. National Museum at Washington, D. C., the British Museum of Natural History at London, the Hope Museum of Oxford University at Oxford, the Naturhistoriska Riksmuseet at Stockholm, and the Museum d'Histoire Naturelle at Paris.

I wish to thank Mr. C. F. W. Muesebeck of the U.S. National Museum, Washington, D. C., for verifying the synonymies of the genera in the family Braconidæ; and Dr. B. D. Burks of the U. S. National Museum for verifying the synonymies of the chalcid genera; also the curators of the various collections for the privilege of studying the material in their care.

Family BRACONIDÆ

AGATHIDINÆ

Genus EUAGATHIS Szepligeti, 1900

Chromomicrodus Ashmead, Proc. U. S. Nat. Mus. **23** (1900) 129. **New synonymy.**

Genotype: *Chromomicrodus abbotti* Ashmead. By monotypy.

Holotype: Female, Siam (Washington). This is a *Euagathis*. The fore and middle claws are bifid; the ovipositor does not extend beyond the tip of the abdomen; the submediellan cell is small, its length does not reach the basal third of the mediella; and the frontal depression is not bordered by a carina.

BRACONINÆ

Genus EUUROBRACON Ashmead, 1900

Delmira Cameron, Mem. and Proc. Manchester Lit. Philos. Soc. **44** (1900) 87. **New synonymy.**

Genotype: *Delmira triplagiata* Cameron, by monotypy.

Holotype: Female, Khasia (Oxford). The features that place it in the genus *Euurobracon* are: nervulus postfurcal, recurrent vein antefurcal, face wide ventrally, first tergite with a deep median groove on its basal third, and ovipositor sheath about 1.5 times as long as fore wing.

Genus GRONAULAX Cameron, 1910

Neuraulax Roman, Arkiv f. Zool. (24) **8** (1913) 4. **New synonymy.**

Genotype: *Neuraulax semperi* Roman. By monotypy.

Types: 3 females, Philippine Islands, "Saloc" (perhaps Sailoc) and Maputi, Surigao (Stockholm).

Lectotype hereby designated: Female, labeled "Saloc u. Maputi, Mindanao. This species is similar to the genotype *Gronaulax pilosellus* Cameron as follows: First tergite long, about 1.5 times its apical width; notaulus deeply impressed over the entire length of mesoscutum; subgenital plate of female pointed apically and extending beyond tip of last tergite; radial vein ending at apex of wing; scape longer than its diameter; second tergite with a midbasal triangular area and two apically convergent lateral carinæ; ovipositor sheath about twice the length of fore wing.

HELCONINÆ

Genus HELCON Nees, 1814

Edyia CAMERON, Ann. Mag. Nat. Hist. (7) **16** (1905) 159. New synonymy.

Genotype: *Edyia annulicornis* Cameron. By monotypy.

Holotype: Male, Kuching, Borneo (London). The ventral side of hind femur is rough or irregularly serrate but without a ventral tooth.

OPIINÆ

Genus OPIUS Wesmæl, 1855

Tolbia CAMERON, Trans. Linn. Soc. London (2) **12** (1907) 84. New synonymy.

Genotype: *Tolbia scævolæ* Cameron. By monotypy.

Holotype: Female, Chagos, Salmon Atoll, Ile de la Passe, July, 1905. Bred from mines in Scoevolta (London). The occipital carina is obsolescent dorsally, but the space between clypeus and mandibles is narrow. The wing venation and first tergite is like that of *Opius.*

ROGADINÆ

Genus CONSPINARIA Schulz, 1906

Paragyroneuron BAKER, Philip. Jour. Sci. § D **12** (1917) 284, 318. New synonymy.

Genotype: *Paragyroneuron bicolor* Baker. By monotypy.

Holotype: Female, Benguet, Mountain Province, Philippines (Washington). This is a subspecies of the genotype of *Conspinaria, C. pilosa* (Cameron); therefore, *Conspinaria pilosa bicolor* Baker is a **new combination** and has a **new** status. In *C. pilosa pilosa* (Cameron) the wings are clear (yellow and black in *bicolor*), veins are yellow except for the dark base of stigma, the body is yellowish-brown or lighter than in bicolor, tergites 4 and 5 have shallower punctures and weaker striæ on the second tergite than *bicolor.*

Genus MACROSTOMION Szepligeti, 1900

Macrostomionella BAKER, Philip. Jour. Sci. § D **12** (1917) 283, 294. New synonymy.

Genotype: *Macrostomionella philippinensis* Baker. By original designation.

Holotype: Female, Mount Maquiling, Laguna, Philippines (Washington). This may be characterized as follows: Middle and hind tibial spurs long and strongly curved, tarsal claws each with a basal lobe, propodeal spiracle elliptical, postnervellus lacking, first intercubitus and second abscissa of radius equal in thickness, first intercubitus straight and oblique, first tergite twice as long as its apical width.

Genus DEDANIMA Cameron, 1903

Colastomion BAKER, Philip. Jour. Sci. § D **12** (1917) 283, 290. New synonymy.

Genotype: *Colastomion abdominalis* Baker. By monotypy and original designation.

Holotype: Female, Mount Banahao, Laguna, Philippines (Washington). This is similar to *Dedanima longicornis* Cameron, the type of the genus, in the following characters: Middle and hind tibial spurs long and strongly curved; tarsal claws simple, without a basal lobe; propodeal spiracle small and circular; postnervellus absent; maxillary palpus in female not enlarged.

STEPHANISCINÆ

Genus HALYCÆA Cameron, 1903

Cendebeus CAMERON, Jour. Straits Branch Roy. Asiatic Soc. **44** (1905) 105. New synonymy.

Genotype: *Cendebeus filicornis* Cameron. By monotypy.

Types: Male, female, Borneo (London). These specimens were compared with the type of *Halycæa*, also from Borneo, and found to be congeneric. They are similar as follows: First tergite long, about 3 times as long as its apical width, rugoso-punctate; second tergite with a median triangular raised area near base; postnervellus straight; subdiscoideus issuing below middle of second discoidal cell.

DORYCTINÆ

Genus EUSCELINUS Westwood, 1882

Sbeitla WILKINSON, Stylops **3** (1934) 83. New synonymy.

Genotype: *Sbeitla furax* Wilkinson. By monotypy and original designation.

Holotype: Female, Ferozepur, India (London). The hind femur is enlarged and with ventral teeth. The subdiscoideus issues above the middle of discoidal cell.

Family ICHNEUMONIDÆ

Genus MESOCHORUS Gravenhorst, 1829

Edrisa CAMERON, Tijds. Ent. **50** (1907) 111. New synonymy.

Genotype: *Edrisa pilicornis* Cameron. By monotypy.

Holotype: Female, Sikkim, India (London). The areolet is large and rhombic; the transverse carina below the antennæ is with a sharp median dip; upper end of prepectal carina does not reach the rim of the mesopleural margin.

Townes (in Proc. Ent. Soc. Washington **59** (1957) 120) synonymized *Zamesochorus* Viereck with *Edrisa*. *Zamesochorus* has an oblique trapeziform areolet, higher than wide and broader at its apex than at its base.

Family EUCHARITIDÆ

Genus CHALCURA Kirby, 1886

Rhipipallus KIRBY, Jour. Linn. Soc. London, Zool. **20** (1886) 31. New synonymy.

Genotype: *Eucharis volusus* Walker. By monotypy and original *designation.*

Holotype: Male, King George's Sound, Australia (London). The scutellum is without a process, wings are clear and the antenna is 12-segmented and pectinate.

Genus SCHIZASPIDIA Westwood, 1835

Lætocantha SHIPP, Entomologist **27** (1894) 188. New synonymy.

Genotype: *Thoracantha nasua* Walker. By monotypy and original designation.

Types: 2 males, Philippine Islands ("British Museum" should be Oxford). The scutellum is bifurcate apically and with the scutellar processes long.

Psygmatocera ENDERLEIN, Ent. Mitt. **1** (1912) 146. New synonymy.

Genotype: *Psygmatocera ceylonica* Enderlein. By monotypy and original designation.

I did not see the type of *Psygmatocera* but basing on the description the scutellum has two long apical processes.

Family PTEROMALIDÆ

Genus SOLENURA Westwood, 1868

Thaumasurelloides GIRAULT, Philip. Jour. Sci. **32** (1927) 554. New synonymy.

Genotype: *Tharmasurelloides silvæ* Girault. By monotypy and original designation.

Type: Female, Mount Maquiling, Laguna, Philippines (Brisbane). Mr. E. F. Riek of the Commonwealth Scientific and Industrial Research Organization, Canberra, Australia, kindly examined the type specimen for me and agreed that *T. silvæ* Girault is a *Solenura.* The female abdomen is very much prolonged, tergites 1 to 3 conic-ovate, beyond the third stylate. The pronotum is prolonged anteriorly into a neck and notaulus is complete.

Family DAIPRIIDÆ

Genus LIPOGLYPTUS Crawford, 1910

Aparamesius KIEFFER, Insecta **3** (1913) 436. New synonymy.

Genotype: *Aparamesius carinatus* Kieffer. By original designation.

Types: 2 males, female, Los Baños, Laguna, Philippines (Paris). These specimens are similar to the type of *Lipoglyptus*, *L. primus* Crawford, in the following characters: Antenna with 13 segments in both sexes, in the male antennal segments 2 and 3 ringlike; one scutellar fovea present; subcosta ending at about the midlength of wing; notaulus absent.

Family SCELIONIDÆ

Genus HABROTELEIA Kieffer, 1905

Chrestoteleia KIEFFER, Insecta **3** (1913) 388. New synonymy.

Genotype: *Chrestoteleia bakeri* Kieffer. By monotypy and original designation.

Types: Male, female, Los Baños, Laguna, Philippines (Paris).

Lectotype designated by Kelner, 1958: Female, Los Baños, Laguna (Paris). The distinguishing features are as follows: First tergite with a basal protrusion, notaulus present, malar groove present, mandible bidentate, postmarginal vein absent, two carinæ joining the tegula and anterior coxa.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), L

By Charles P. Alexander
Amherst, Massachusetts

THREE PLATES

The present report continues the consideration of the crane-flies that were taken in the Himalayas of northern India by Dr. Fernand Schmid, together with the description of two further species from South India, taken by Mr. P. Susai Nathan. I wish to extend my deep thanks to the collectors for the privilege of studying these unusually interesting flies. All species discussed at this time belong to the genus *Tipula*, exceptionally well developed in India and particularly throughout the extent of the Himalayas.

TIPULINÆ

TIPULA (BELLARDINA) SAVTSHENKOI sp. nov. Plate 1, fig. 5.

Allied to *thibetana;* mesonotal præscutum with four light brown stripes, the intermediate pair widely separated by a more yellowed central area; frontal prolongation of head chestnut brown, without nasus; thoracic pleura brownish yellow, variegated with darker brown; legs yellowish brown, outer tarsal segments darker; wings brownish gray, restrictedly patterned with darker brown, delicately reticulated with yellow, especially in the basal cells, these lines in cells M and 1st A nearly transverse; wing margin conspicuously darkened, interrupted by a central whitened spot in each cell from M_1 to 2nd A; outer radial field with a complete Y-shaped mark; male hypopygium without blackened spinules on tergite, the latter produced medially into a sclerotized structure; outer dististyle with apex elongate, provided with abundant small black setæ; inner dististyle small, its base without dense hair.

Male.—Length, about 23 millimeters; wing, 22; antenna, about 4.2.

Frontal prolongation of head elongate, dark chestnut brown, without nasus; palpi with first and last segments brownish black, intermediate segments brown. Antennæ with scape brown, pedicel yellow, flagellum brownish black; basal enlargements of flagellar segments small; verticils very long, much

exceeding the segments. Head dark brown above, the anterior orbits narrowly brightened; vertical tubercle conspicuous, narrowly compressed.

Pronotum brown medially, the sides of the scutum light pruinose. Mesonotal præscutum with disk chiefly occupied by four light brown stripes, the intermediate pair widely separated by a more yellowed central vitta that narrows behind; interspaces narrow, virtually concolorous; humeral and lateral borders dark brown; scutal lobes dark brown, vaguely freckled with small orange spots, margins and central area gray; scutellum brownish gray, with a light gray central line; mediotergite light gray, with a large brown area on either side of midline, posterior border more yellowed; vestiture of præscutum, scutum and mediotergite long and conspicuous; pleurotergite light brown, the katapleurotergite dark brown, narrowly lined above with silvery, the lower third brownish yellow. Pleura brownish yellow, variegated with darker brown on the propleura, dorsal anepisternum and sternopleurite, as well as the dorsal pteropleurite and metapleura. Halteres with stem yellow, knob infuscated. Legs with coxæ light brown, posterior pair more grayish brown; trochanters yellow, lower face patterned with black; remainder of legs light yellowish brown, the ouster tarsal segments passing into black; tooth of claws triangular, the breadth at base subequal to the length. Wings with the ground brownish gray, restrictedly patterned with darker brown, delicately reticulated with yellow lines; the darker areas include marks at origin of Rs, two in cell M adjoining vein Cu; at midlength of cell Cu and a smaller mark immediately behind in cell 1st A; the entire margin is similarly darkened but interrupted by conspicuous whitened spots in centers of cells M_1 to M_4, two in 1st A and one in 2nd A; a conspicuous Y-shaped area in cells R_3 and R_5, the arms reaching the margin; stigma dark brown, its center obscure yellow along vein R_1, preceded by a narrow white prestigmal spot; yellow areas in basal cells more nearly straight and transverse than in *thibetana*, especially in cells M and 1st A; pale areas beyond cord and stigma and caudad of cell 1st M_2, more conspicuous in bases of cells M_3 and M_4; pale obliterative areas in outer end of cell R and across cell 1st M_2; veins yellow, very narrowly and insensibly bordered by the same color. Macrotrichia on most longitudinal veins beyond cord, becoming sparse and scattered on basal parts, Sc, M and 1st A with trichia virtually over their whole length; base of Cu_1 glabrous, with a

series of five punctures beyond arculus; prearcular anal vein with abundant trichia. Venation: Rs about one-half longer than m-cu.

Abdomen reddish brown, the basal rings of the more proximal tergites with a dark brown lateral spot, margins of posterior rings yellowish gray. Male hypopygium (Plate 1, fig. 5) with the tergite, *t*, semioval in outline, the posterior border convexly rounded, with long black setæ, the central part produced into a sclerotized structure, as figured. Outer dististyle, *d*, long, boomerang-shaped, strongly bent beyond midlength, the slender outer part with abundant small black setæ, at the point of bending with two flattened flanges, one more slender, the broader flange with several blackened points at apex; inner style much smaller, strongly arcuated, the apex with pale membrane, outer surface at near midlength with black setæ.

Habitat.—Sikkim.

Holotype, male, Namnasa, altitude 9,500 feet, July 12, 1959 (*Schmid*).

I am pleased to dedicate this fly to Dr. E. N. Savtshenko, outstanding student of the Eurasian Tipulidæ. The species agrees most closely with *Tipula* (*Bellardina*) *thibetana* de Meijere, disagreeing in important features of coloration and structure of the male hypopygium. The type of *thibetana* was re-examined and discussed by Edwards (Ann. Mag. Nat. Hist. (10) **1** (1928) 686, fig. 3 (wing).

TIPULA (SCHUMMELIA) APPENDIFERA Alexander. **Plate 1, fig. 6.**

Tipula (*Schummelia*) *appendifera* ALEXANDER, Ann. Mag. Nat. Hist. (12) **8** (1955) 661–663.

The types were from Nuristan, East Afghanistan, collected by Klapperich. Additional material from Pakistan and Sikkim indicates a wide range in the Himalayas; Chatorkhand, Pakistan, altitude 6,850 feet, July 31, 1954 (*Schmid*); Kai Gah, Kashmir, altitude 8,000 feet, July 7, 1953 (*Schmid*); Lachung, Sikkim, altitude 8,610 feet, July 9, 1959 (*Schmid*).

The distinctive male hypopygium is re-described and figured (Plate 1, fig. 6). Posterior end of tergite, *t*, rounded, on either side with a large subcircular plate, nearly glabrous, margins blackened; median area in cases slightly produced (as shown), in others retracted. Outer dististyle, *d*, long and slender, tapering to the narrow obtuse tip; inner style massive, beak stout, lower beak lacking; on face of style at base with a large lobe

that presumably represents the outer basal lobe, its surface microscopically roughened. Phallosome, *p*, with a conspicuous blackened apophysis on either side, subtending the broad membranous ædeagus. Eighth sternite with posterior border gently convexly rounded, unmodified except for abundant setæ over about the posterior third.

TIPULA (SCHUMMELIA) ARGENTACEA sp. nov. Plate 1, fig. 7.

Size relatively large (wing of male 13.5 millimeters); mesonatal præscutum obscure yellow with four olive-brown stripes; scutum and scutellum with a capillary brown median line; katapleurotergite tumid, silvery; antennæ with basal three segments yellow, succeeding segments weakly bicolored; wings broad, brownish yellow, weakly patterned with darker brown and cream colored areas, the former including a major cloud over m-cu, prearcular and costal fields yellow; cell M_1 sessile, cell 1st M_2 small; male hypopygium with the posterior border of tergite broadly emarginate, unmodified; no hair pencils on ninth sternite; inner dististyle with beak slender, basal lobe with microscopic spinules.

Male.—Length, about 13 millimeters; wing, 13.5; antenna, about 3.5.

Frontal prolongation about two-thirds the remainder of head, orange yellow above, narrowly darkened on sides, light yellow beneath; nasus distinct, palpi with proximal two segments obscure yellow, remainder black. Antennæ with proximal three segments yellow, the second flagellar black at base, apex obscure yellow, succeeding segments vaguely bicolored, base black, apex dark brown, fifth and remaining segments black; segments subequal in length to the unilaterally arrange elongate verticils, basal enlargements moderate. Head brownish yellow, vertical tubercle chestnut brown, the area narrowed posteriorly, reaching the occiput as a slender line.

Pronotum obscure yellow, variegated by three large more olive brown areas. Mesonotal præscutum obscure yellow, clearer on the posterior interspaces, disk virtually covered by four olive brown stripes, the intermediate pair and mesal margins of the laterals darker brown; scutum broadly light yellow medially, the lateral two-thirds of each lobe more darkened, central line dark brown; scutellum yellow with a central brown vitta, parascutella infuscated; mediotergite yellow, with sparse black setæ laterally on posterior half; anapleurotergite yellow with

a small brown spot at posterior end, katapleurotergite tumid, the anterior half conspicuously light silvery, posterior part more darkened. Pleura olive yellow, more darkened in front, posterior edge of pteropleurite slightly suffused; dorsopleural membrane brown. Halteres with stem obscure yellow, base and knob clearer yellow. Legs with all coxæ and trochanters yellow; femora obscure yellow, tips broadly brownish black; tibiæ dark brown, tips slightly more intense; tarsi brownish back; claws with an acute spine. Wings broad, brownish yellow, prearcular and costal fields conspicuously light yellow; stigma long-oval, dark brown; major brown clouds over m-cu and outer end of cell 1st M_2, with smaller marginal clouds on Cu_1 and 2nd A; small obliterative areas before and beyond stigma and across cell 1st M_2 into cell M_3; cells R and 2nd A slightly darker than remainder of ground; cream colored spots before outer end of cell M and in outer ends of both anal cells; veins brown, conspicuously yellowed in the brightened fields. Macrotrichia of veins long and abundant, on all longitudinal veins beyond cord, including the free tip of Sc_2; basal of cord with trichia on all veins basad to the general level of arculus and on the prearcular anal vein. Venation: Rs shorter than the gently arcuated m-cu; cell M_1 sessile or with its petiole punctiform; cell 1st M_2 small, its outer end pointed; M_{3+4} long, subequal to basal section of M_{1+2}.

Abdomen obscure yellow basally, intermediate segments brown, yellowed basally, hypopygium blackened. Male hypopygium (Plate 1, fig. 7) with the tergite, *t*, transverse, posterior margin broadly and shallowly emarginate, forming broad lateral lobes; border unmodified, narrowly darkened, with sparse inconspicuous setæ. Ninth sternite with scattered setæ of normal length, not forming groups or pencils. Outer dististyle, *d*, relatively long, the length approximately six times the width; inner style flattened, beak slender, base of style with a small suboval lobe that is provided with numerous microscopic spinulæ. Eighth sternite unmodified.

Habitat.—Sikkim.

Holotype, male, Lachung, altitude 8,610 feet, July 9, 1959 (*Schmid*).

Tipula (*Schummelia*) *argentacea* resembles some other regional species in the conspicuous silvery area on the thoracic katapleurotergite, these including *T.* (*S.*) *argentosigna* sp. nov., *T.* (*S.*) *atrosetosa* sp. nov., and *T.* (*S.*) *tanyrhina* sp. nov. All are

readily told among themselves by the coloration of the body and wings and the structure of the head and male hypopygia.

TIPULA (SCHUMMELIA) ARGENTOSIGNA sp. nov. Plate 1, fig. 8.

Size medium (wing of male about 13 millimeters); frontal prolongation of head normal; mesonotal præscutum with disk virtually covered by four brown stripes, katapleurotergite light silvery; wings light brown, variegated by dark brown and pale areas; basal abdominal segments brownish yellow, lateral borders infuscated, outer segments more uniformly dark brown; male hypopygium with a conspicuous pencil of long black setæ on ninth sternite; inner dististyle with beak and lower beak slender spinelike.

Male.—Length, about 10.8 to 11 millimeters; wing, 13 to 13.5; antenna, about 4.2 to 4.3.

Female.—Length, about 15 millimeters; wing, 16; antenna, about 3.

Frontal prolongation of head normal for the subgenus (compare *tanyrhina*), yellow, sides slightly more obscured, dorsum with few setæ, nasus distinct; basal segment of palpus yellow, second segment yellow, tip broadly brownish black, outer segments darker, terminal one black. Antennæ with scape and pedicel yellow, the latter clearer; flagellum with proximal segments very weakly bicolored, bases brownish black, remainder paler, outer segments more uniformly darkened; segments longer than their verticils. Head brown, slightly more yellowed on orbits; vertical tubercle low, with a capillary blackened central vitta.

Cervical region weakly darkened, sides obscure orange. Pronotum clear light yellow above, weakly more darkened on sides. Mesonotal præscutum with disk virtually covered by four brown stripes, posteriorly with slightly paler centers, interspaces similarly darkened, leaving a small yellow spot before suture, lateral border broadly light yellow; scutum brownish yellow, lobes weakly darkened, more intensely so at lateral ends of suture; scutellum brownish yellow, parascutella darker brown; mediotergite obscure orange yellow, with a weak brown darkening on basal half on either side of the broad central area; anapleurotergite obscure orange yellow, katapleurotergite tumid, strikingly white silvery, with a brown spot at either end, the anterior one being on the ventral pteropleurite. Pleura infuscated, slightly variegated with paler; meron and ventral sternopleurite more

yellowed. Halteres with stem infuscated, knob yellowed. Legs with fore coxæ light brown, mid-coxæ yellow, anterior face darkened, posterior coxæ light yellow; trochanters yellow, fore pair darker; femora brown, narrowly blackened at outer end, genua pale; tibiæ dark brown, tarsi passing into black; claws of male toothed. Wings with ground light yellow, with a conspicuous darker brown and pale pattern, prearcular and costal regions yellowed; stigma dark brown; conspicuous paler brown areas at m-cu, outer end of cell 1st M_2, extended to beyond fork of M_{1+2}, and at near midlength of cell M; obliterative area across cell 1st M_2 conspicuously whitened; remaining pale areas slightly more yellowed, placed at origin of Rs, before and beyond stigma, center of cell M_1, and two in cell M, passing into cell Cu behind; a circular marginal spot in cell 1st A adjoining vein 1st A, the latter narrowly seamed with dark brown over its entire length; veins dark brown, more yellowed in the brightened fields. Macrotrichia on most longitudinal veins beyond arculus, lacking on 1st A; prearcular anal vein with sparse trichia. Venation: Rs a trifle longer than the very oblique m-cu; petiole of cell M_1 about twice m; M_{3+4} subequal to m.

Basal abdominal segments brownish yellow, brightest near base, lateral borders infuscated, becoming more extensive on outer segments; basal sternites yellow, outer segments, including the hypopygium, dark brown. Male hypopygium (Plate 1, fig. 8) with the tergite, *t*, brownish black, convexly rounded, posterior border with a deep V-shaped incision, on slide mounts becoming flattened as illustrated, with a low median projection not apparent from above; margin blackened, outer lateral angles farther produced. Ninth sternite, *9s*, with a narrow but conspicuous brush or pencil of long black setæ, directed ventrad. Outer dististyle, *d*, relatively narrow, its length above five or six times the width; inner style with beak slender, lower beak a broad-based spine; outer crest intensely blackened, produced; at base of style with a small triangular blade or lobe. Eighth sternite narrow, posterior border gently convex, unmodified, with moderately long marginal setæ.

Habitat.—Sikkim.

Holotype, male, Chumzomoi Choka, in *Rhododendron* association, altitude 11,800 feet, July 8, 1959 (*Schmid*). Allotopotype, female; paratopotype, male.

Tipula (*Schummelia*) *argentosigna* is still another of the members of the subgenus having a conspicuous silvery mark

on the thoracic katapleurotergite, others being *T.* (*S.*) *argentacea* sp. nov., *T.* (*S.*) *atrosetosa* sp. nov., and *T.* (*S.*) *tanyrhina* sp. nov. The present fly has the head normal, as in *argentacea*, differing in the wing pattern and especially in the male hypopygium, including the tergite, sternite and inner dististyle.

TIPULA (SCHUMMELIA) ATROSETOSA sp. nov. Plate 1, fig. 9.

General coloration of mesonotal præscutum yellow, disk with four brown stripes that are more or less bordered by darker; central line of scutum and scutellum brown, katapleurotergite silvery; pleura yellow below, with a broad dark brown dorsal longitudinal stripe; legs black; wings whitish, prearcular and costal fields conspicuously yellow, a restricted darker pattern; cell M_1 deep, 1st M_2 small; male hypopygium with posterior border of tergite narrowly blackened, tridentate; basistyle with abundant long black setæ; outer dististyle dilated on proximal third; gonapophysis pale, with abundant tubercles that bear very long yellow setæ.

Male.—Length, about 10.5 to 11 millimeters; wing, 11 to 12; antenna, about 3.3 to 3.5.

Frontal prolongation of head dull orange above, more yellowed beneath; nasus distinct, palpi black. Antennæ relatively short; scape and pedicel light yellow, the former elongate; first flagellar segment brownish yellow, second black at base, its pedicel obscure yellow; succeeding flagellar segments black, basal enlargements conspicuous, segments weakly incised above, subequal to their longest verticils. Head brownish yellow, orbits clearer yellow; center of vertex medium brown, on the low vertical tubercle with a capillary black line.

Pronotum brown, paler brown laterally, with restricted obscure yellow sublateral markings. Mesonotal præscutum obscure yellow laterally and on posterior interspaces, disk with four brown stripes, the intermediate pair narrowly bordered by slightly darker brown, the stripes confluent in front, isolating the posterior interspaces, humeral region obscure yellow, lateral borders clearer; scutum with lobes brown, central area obscure yellow with a darker brown median line that is continued back onto the scutellum, the remainder of the latter brownish yellow, parascutella darker; mediotergite obscure orange on central part, more infuscated laterally; pleurotergite brownish yellow, the katapleurotergite brilliantly silvery; mesonotum with relatively long erect setæ. Pleura yellow below, with a broad

and conspicuous dark brown longitudinal stripe extending from the cervical sclerites across the propleura and anepisternum, thence more ventrally onto the abdomen, passing beneath the katapleurotergite. Halteres with base and knob yellow, stem more obscured, especially outwardly. Legs with coxæ and trochanters light yellow; remainder of legs black, femoral bases obscure yellow; claws relatively long, toothed. Wings with the ground whitish, prearcular and costal fields strongly yellowed; stigma long-oval, dark brown; paler brown areas in cell M adjoining vein Cu, over m-cu, and at ends of veins Cu and 2nd A; more evident whitened areas before and beyond stigma and across cell 1st M_2, before outer end of cell M, two marginal areas in cell 1st A, a single one in 2nd A; veins dark brown, more yellowed in the brightened parts. Macrotrichia of veins abundant, extending basad virtually to arculus, including abundant trichia on m-cu, m and the prearcular anal vein. Venation: Rs straight, much shorter than m-cu; petiole of cell M_1 very short to nearly punctiform, the longest about one-half m; cell 1st M_2 small; m-cu at fork at M_{3+4} or just beyond on M_4.

Basal abdominal tergites yellow, outer ones more obscure, sides of first segment with a brown spot; basal sternites yellow, outer segments passing into black. Male hypopygium (Plate 1, fig. 9) with the tergite, *t*, transverse, posterior border with central area narrowly blackened, tridentate, the lateral teeth more acute; lateral tergal lobes broader, pale. Basistyle, *b*, with abundant long black setæ that do not form brushes. Outer dististyle, *d*, pale, relatively short, conspicuously expanded on basal third; vestiture of black setæ, on outer margin with a few exceedingly long yellow setæ, the longest exceeding one-half the length of the style (not figured); inner style long but broad, beak slender, blackened, lower beak blunt, triangular; region of outer basal lobe reflexed, its margin microscopically denticulate. Gonapophysis, *g*, small, yellow, with abundant tubercles that bear yellow setæ of unusual length. Ædeagus broad, sclerotized on sides. Eighth sternite large, posterior border truncate; abundant long black setæ on about the outer two-thirds of the plate.

Habitat.—Sikkim.

Holotype, male, Nanga, altitude 5,000 feet, August 4, 1959 (*Schmid*). Paratopotype, 1 male, August 3, 1959; paratypes, male, Manu, altitude 4,920 feet, May 10, 1959 (*Schmid*); male, Teng, altitude 4,600 feet, August 1, 1959 (*Schmid*).

Tiplua (*Schummelia*) *atrosetosa* is still another species having the thoracic katapleurotergite brilliantly silvery, others being *T.* (*S.*) *argentacea* sp. nov. and *T.* (*S.*) *argentosigna* sp. nov., together with the more isolated *T.* (*S.*) *tanyrhina* sp. nov. All of these species differ among themselves in the details of coloration and structure of the male hypopygium.

TIPULA (SCHUMMELIA) DRAVIDIANA sp. nov. Plate 1, figs. 1, 10.

Size small (wing of male about 10 to 11 millimeters); mesonotal præscutum brownish yellow, with two intermediate brown stripes, scutellum pale, pleura unpatterned; femora obscure yellow, with a narrow brown subterminal ring, tibiæ and tarsi black, claws simple; wings weakly tinged with brown, stigma oval, darker brown, conspicuous obliterative areas before and beyond stigma; cell M_1 deep, m-cu long, at or close to the fork of M; abdominal tergites conspicuously patterned yellow and brown; male hypopygium with the tergite produced medially.

Male.—Length, about 10.5 millimeters; wing, 10.8.

Female.—Length, 12 to 13 millimeters; wing, 10 to 11.5.

Frontal prolongation of head buffy yellow with conspicuous black setæ; nasus elongate; palpi dark brown. Antennæ with basal three segments yellow, succeeding segments bicolored, the basal enlargements black, the more extensive pedicels yellow (antennæ of type male broken beyond the eighth segment), segments a trifle longer than the single modified verticil; antennæ of female shorter but comparably colored, the outer flagellar segments uniformly darkened. Head light yellow in front, including the sides of the low vertical tubercle; posterior vertex brownish gray medially, clearer brown on sides and here with conspicuous black setæ.

Pronotum buffy. Mesonotal præscutum with the ground brownish yellow, with two brown intermediate stripes that are narrowly separated by a ground vitta, sides of præscutum slightly darker; scutum with central area whitened, lobes, brown; scutellum whitened, with a dark depressed area on either side at base; mediotergite whitened, darker behind and on sides; pleurotergite brownish yellow, the posterior end brown. Pleura pale yellow, with a small darkened area beneath the wing root. Halteres with stem yellow, knob dark brown, its apex yellowed. Legs with coxæ and trochanters yellow; femora obscure yellow with a narrow brown subterminal ring; tibiæ and tarsi black; claws of male very small, simple. Wings (Plate 1, fig. 1) weakly

tinged with brown, stigma oval, dark brown; narrow dark seams over m-cu and less evidently on distal section of Cu_1 and petiole of cell M_1; whitened obliterative areas before and beyond stigma and across base of cell 1st M_2; elsewhere on disk with vague brightenings in certain of the cells; veins brown, yellow in the obliterative parts. Macrotrichia on veins almost to wing base. Venation: R_{1+2} entire but pale, without trichia; Rs short and nearly straight, about two-thirds R_{2+3}; cell M_1 deep from four to five times its petiole; cell 1st M_2 small, irregularly pentagonal, m being distinct; m-cu long, oblique, at or near the fork of M.

Abdomen yellow, tergites margined posteriorly and laterally with brown, more extensively so on the eighth segment; sternites yellow; hypopygium brownish yellow. Male hypopygium (Plate 1, fig. 10) with the tergite, *t*, transverse, the posterior margin produced into a median lobe, pointed at tip, carinate above, the sides with numerous small pale setulæ, lateral lobes lower, broadly rounded. Outer dististyle, *d*, short and broad, the apex very obtuse; inner style oval, beak blackened, long-produced; disk with numerous setæ, including a modified group of five or six at posterior end, in the same region with about eight large pale circular sensory pores. Phallosome with the apophyses appearing as pale flattened blades, longer than the dark colored ædeagus. Eighth sternite with the margin generally unmodified but with a very low lobe on either side, bearing scattered elongate black setæ.

Habitat.—South India.

Holotype, male, Cherangode, Nilgiri Hills, altitude 3,300 feet, November 9, 1950 (*Susai Nathan*). Allotype, female, Cinchona, Anamalai Hills, altitude 3,500 feet, May 1956 (*Susai Nathan*). Paratypes, 3 females, with the allotype.

The most similar species in the Oriental fauna include *Tipula* (*Schummelia*) *modica* Alexander, *T.* (*S.*) *picticornis* (Brunetti), *T.* (*S.*) *turea* Alexander, and *T.* (*S.*) *vocator* Alexander, all differing in details of coloration and, especially, in the structure of the male hypopygium.

TIPULA (SCHUMMELIA) FUSCOCELLULA sp. nov. Plate 1, fig. 11.

Size medium (wing about 12 millimeters); mesonotal præscutum yellow with three brown stripes; front of head with a brown median line extending almost to base of prolongation; basal flagellar segments weakly bicolored; femora obscure yel-

low, tips blackened; wings pale brown, weakly patterned with darker brown and white, cell Sc uniformly darkened; call M_1 deep; male hypopygium with posterior border of tergite broadly emarginate, with a low blackened central lobe, lateral lobes beneath with a blackened tooth; outer dististyle long and narrow; inner style with beak very slender, on disk with an area of blackened setæ.

Male.—Length, about 11 millimeters; wing, 12.5; antenna, about 4.

Frontal prolongation yellow above, including the long nasus, sides more infuscated; palpi black. Antennæ with scape and pedicel yellow, flagellar segments weakly bicolored, the small basal enlargements dark brown, outer ends paler brown, the bicolorous pattern persisting almost throughout; segments slightly exceeding their longest verticils. Head with front and anterior vertex yellow, the posterior part of head infuscated, sending a median line forward between the antennal bases, expanded in front and reaching almost to base of prolongation, becoming a capillary line on the very low vertical tubercle.

Pronotal scutum chiefly brown, scutellum yellow, dark brown on sides. Mesonotal præscutum yellow laterally, more brownish yellow on the interspaces, with three brown stripes that are vaguely bordered by still darker, the broad central stripe entire; scutum obscure yellow, each lobe with two confluent dark brown areas; scutellum obscure yellow with a broad central darkened stripe, parascutella brown; mediotergite yellow with a broad brown stripe on either side of the narrower pale center; pleurotergite brownish yellow, the tumid katapleurotergite vaguely silvery. Pleura yellow, conspicuously patterned with dark brown, appearing as two broken stripes, the dorsal one including the cervical region, propleura, most of the anepisternum and the dorsal pteropleurite; ventral stripe involving the ventral sternopleurite and meron; setæ of notum pale. Halteres with stem yellowish brown, darker outwardly, base of stem and apex of knob obscure orange yellow. Legs with coxæ yellow, fore pair narrowly darkened basally; trochanters yellow; femora obscure yellow, tips rather narrowly blackened; tibiæ and basitarsi yellowish brown, outer tarsal segments black; claws toothed. Wings pale brown, with a weak pattern of darker brown and whitened spots; cell Sc almost uniformly dark brown, the extreme outer end yellowed; stigma dark brown; the darkest clouds occur at outer end of cell M and in outer radial

field, the chief whitened areas being poststigmal, across cell 1st M_2, near outer end of cell M and in outer end of cell 1st A; no brightening in cell 2nd A; veins brown. Macrotrichia on longitudinal veins beyond cord, including a few on m; before the cord extending basad virtually to the arculus on Sc, R, M and both anals, extensively so but more scattered on Cu_1; squama naked. Venation: Cell 1st M_2 relatively large; cell M_1 deep, its petiole shorter than m; Rs a trifle longer than m-cu.

Abdominal tergites brownish yellow, the basal segments clearer yellow, lateral borders broadly brownish black, interrupted by pale posterior borders; basal sternites yellow, vaguely patterned with darker; outer two segments, including base of hypopygium, black, the appendages yellowed. Male hypopygium (Plate 2, fig. 11) with the tergite, *t*, transverse, posterior border broadly emarginate, with a low central blackened projection and rounded lateral lobes, the latter with a slender blackened tooth on ventral surface. Outer dististyle, *d*, long and slender, pale, tapering gradually to the narrowly obtuse tip; inner style with the beak very slender, dorsal crest virtually lacking; outer basal lobe large and flattened; disk of style with a linear area of strong blackened setæ. Gonapophysis, *g*, large, obtuse, with long yellow setæ from inconspicuous punctures. Eighth sternite narrow, its posterior border truncate, unmodified, with setæ restricted to about the posterior fourth.

Habitat.—Pakistan.

Holotype, male, Surgun Sur, Northwest Frontier Province, altitude 6,875 feet, July 29, 1953 (*Schmid*).

Tipula (*Schummelia*) *fuscocellula* agrees with *T.* (*S.*) *nigrocellula* Alexander in the uniformly darkened subcostal cell, differing in details of coloration of the body and wings and, especially, in the structure of the male hypopygium. In *nigrocellula*, the outer dististyle is small and weak and the inner style is differently constructed.

TIPULA (SCHUMMELIA) NANNARIS sp. nov. **Plate 1, fig. 12.**

General coloration of mesonotum brown, mediotergite uniformly darkened; pleura yellow, patterned with brown; knobs of halteres brownish black; tibiæ and tarsi brownish black; wings almost uniformly infuscated, very restrictedly patterned with paler; cell 1st M_2 small, hexagonal; male hypopygium with the ninth tergite shallowly emarginate, the lobes broadly rounded and thickened; outer dististyle long and slender, inner style with

beak slender, lower beak much larger, heavily blackened, basal lobe small, darkened.

Male.—Length, about 10 millimeters; wing, 11; antenna, about 4.

Frontal prolongation of head yellow, the angle with remainder of head acute; nasus elongate, yellow; palpi dark brown, terminal segment elongate, subequal to the combined remaining segments. Head cinnamon brown behind, narrowly darkened on occiput, front and anterior vertex yellow, without a vertical tubercle.

Cervical region above and the pronotal scutum dark brown, the latter variegated with obscure yellow; scutellum yellow medially, lateral angles narrowly blackened. Disk of mesonotal præscutum with four brown stripes that are narrowly bordered by darker brown, the intermediate pair confluent behind; posterior interspaces and anterior ends of intermediate stripes brownish yellow, lateral borders and humeri broadly yellow; scutum almost uniformly brown, including the central region; scutellum yellowish brown with a narrow dark brown central line, parascutella dark brown; mediotergite uniformly medium brown, with scattered erect yellow setæ; pleurotergite medium brown above, the summit of the tumid katapleurotergite more yellowed, not silvery. Pleura yellow, the propleura, anepisternum and dorsal sternopleurite infuscated; dorsopleural membrane variegated yellow and brown. Halteres with stem obscure yellow, knob brownish black. Legs with all coxæ and trochanters yellow; femora brownish yellow, tips narrowly black; tibiæ and tarsi brownish black; claws toothed. Wings with the ground almost uniformly infuscated, very restrictedly variegated by small pale areas before and beyond stigma, across cell 1st M_2, and very vaguely at and near outer ends of cells M and 1st A; no brightening in cell 2nd A; stigma dark brown; veins dark brown. Macrotrichia on most longitudinal veins beyond arculus and on preanal vein, lacking on m-cu. Venation: Rs gently arcuated, subequal to m-cu; cell M_1 deep, its petiole and m subequal; cell 1st M_2 small, hexagonal; m-cu on M_{3+4} at near two-thirds the length.

Abdominal tergites dark brown, the more proximal segments slightly more brownish yellow basally; proximal sternites obscure yellow; outer segments, including hypopygium, brownish black. Male hypopygium (Plate 1, fig. 12) with the tergite, *t*, large, blackened, posterior border emarginate forming broad

rounded lobes with thickened margins, each produced beneath into a small tooth. Outer dististyle, *d*, long and slender, pale throughout; inner style yellow, beak slender, lower beak much broader, blackened; a small dark basal lobe; disk with inconspicuous yellow setæ. Sternal cushions densely provided with short yellow setæ, with fewer very long yellow bristles.

Habitat.—Sikkim.

Holotype, male, Manu, altitude 4,920 feet, August 5, 1959 (*Schmid*).

Tipula (*Schummelia*) *nannaris* is readily told from all regional members of the subgenus by the blackened knobs of the halteres and the almost uniformly darkened wings, with very restricted pale pattern. The structure of the hypopygium, especially the tergite, sternite and inner dististyle, provide distinctive characters.

TIPULA (SCHUMMELIA) TANYRHINA sp. nov. **Plate 1, fig. 13.**

Size medium (wing about 13 millimeters); frontal prolongation of head elongate, exceeding the remainder of head; mesonotal præscutum with four brown stripes that are broadly margined with darker brown, mediotergite obscure orange, katapleurotergite conspicuously silvery; pleura brown; knobs of halteres orange; legs with femora obscure yellow, tips narrowly blackened; wings cream yellow with a very heavy darker pattern; basal abdominal tergites brown, outer segments black; male hypopygium with the tergite transverse, its posterior border shallowly emarginate.

Male.—Length, about 11.5 to 12 millimeters; wing, 13 to 13.5; antenna, about 4.5 to 4.8; frontal prolongation alone, about 1.3 to 1.4.

Frontal prolongation of head of unusual length, slightly exceeding the remainder of head, yellowed above, on sides yellowish brown to light brown, without nasus; palpi with proximal three segments brown, terminal segment black; head above, including the prolongation, flattened, without an angle or emargination at base of the latter, as usual in the genus. Antennæ with scape light to dark brown, pedicel yellow, flagellum black; flagellar segments with small basal enlargements, basal segment unusually long, nearly equal to the second and third combined, verticils shorter than the segments. Head above chiefly brown, including a central area, the front and broad orbits yellow, in

cases the posterior vertex more extensively darkened; a small dark spot immediately behind each antennal fossa.

Pronotum yellow medially, broadly more darkened on sides. Mesonotal præscutum chiefly covered by four brown stripes that are broadly margined with darker brown, posterior interspaces obscured, humeral and lateral borders broadly light yellow; scutal lobes infuscated, especially anteriorly, central region obscure yellow; scutellum light brown, obscure yellow medially, parascutella testaceous; mediotergite obscure orange, pleurotergite orange, the katapleurotergite bright silvery. Pleura brown, more yellowed behind; dorsopleural membrane yellow. Halteres with stem weakly infuscated, obscure yellow at base, apex of knob orange. Legs with coxæ yellow, basal half of fore pair darkened; trochanters brownish yellow; femora obscure yellow, tips narrowly blackened; tibiæ brownish yellow, tips very narrowly infuscated; basitarsi brownish yellow, outer segments passing into black; claws with a slender subbasal tooth. Wings with the restricted ground cream yellow, with a very heavy grayish brown pattern, including still darker brown areas beyond arculus, at midlength and in outer end of cell M, outer end of cell 1st M_2, and tip of vein 2nd A; stigma darker brown; the chief ground areas are before and beyond the stigma, bases of cells M_1 and 2nd M_2, and more extensively in cell M and near outer end of the anal cells; obliterative area at base of cell 1st M_2 more whitened, extensive, invading cells M and M_3; cell C pale brown, Sc light yellow; veins brown, Sc and R yellow. Macrotrichia on most veins beyond cord, including also Sc and, in cases, Rs; on M sparse and scattered, lacking on basal section of Cu_1; sparse and scattered on anal veins, especially 1st A; a nearly complete series on the prearcular anal vein. Venation: Rs long, from about one and one-half to nearly twice R_{2+3} and slightly exceeding m-cu; petiole of cell M_1 subequal to or shorter than m.

Abdominal tergites brown, posterior borders narrowly paler, basal sternites more yellowed, outer segments black; appendages of hypopygium obscure yellow. Male hypopygium (Plate 1, fig. 13) with the tergite, *t*, transverse, posterior border very shallowly emarginate, blackened, ventral surface on either side with low denticles. Ninth sternite a small darkened cushion with relatively few long scattered setæ. Outer dististyle, *d*, of moderate length, the greatest width about one-fourth to one-fifth the length; inner style with lower margin of beak blackened, the paler base

of style disconnected by a constriction; apex of beak obtusely rounded. Eighth sternite unarmed.

Habitat.—Sikkim.

Holotype, male, Chumzomoi Choka, altitude 11,800 feet, in *Rhododendron* association, July 8, 1959 (*Schmid*). Paratopotypes, males, July 8, 1959.

Tipula (*Schummelia*) *tanyrhina* is readily told from other known species by the elongated frontal prolongation of the head, in conjunction with a marked flattening of the vertex. In life it was associated with *T.* (*S.*) *argentosigna* sp. nov., having the structure of the head normal and unmodified.

TIPULA (YAMATOTIPULA) BHOTEANA sp. nov. Plate 2, fig. 14.

Size small (wing of male about 11 millimeters) ; general coloration gray, præscutum with four more blackened stripes; antennæ long, black, pedicel yellow; legs black, bases of fore femora narrowly yellow, claws small, simple; wings cream yellow, bright yellow at base, restrictedly patterned with darker; male hypopygium with tergite emarginate; outer dististyle darkened, inner style simple, its beak powerful, cleaverlike, with few modifications; gonapophyses paddlelike.

Male.—Length, about 9.8 to 10 millimeters; wing, 11 to 11.2; antenna, about 6.

Frontal prolongation of head relatively long, somewhat shorter than the remainder, black, including the nasus; palpi black throughout. Antennæ of male of unusual length, exceeding one-half the body or wing; black, pedicel obscure yellow; flagellar segments subcylindrical, with very small basal enlargements; segments with a dense white pubescence and slightly longer verticils, the longest of the latter about one-third the length of the segment. Head brownish gray, clearer gray in front and on orbits; vertical tubercle low, rounded; eyes small, anterior vertex very broad; genæ prominent, with long coarse setæ.

Pronotum blackened, sparsely pruinose. Mesonotum gray, disk of præscutum with four more blackened stripes, lateral borders dull black, setæ pale and appressed; posterior sclerites dull black, gray pruinose, mediotergite with a vague more blackened capillary central line, pleurotergite blackened; scutellum with long pale setæ, postnotum glabrous. Pleura dull black, variegated by gray areas, including a more or less distinct longitudinal stripe across the propleura, dorsal sternopleurite, ventral pteropleurite and metapleura; dorsopleural region dark brown.

Halteres with stem brown, obscurely brightened at base, knob brownish black. Legs with coxæ gray pruinose; trochanters brownish black; remainder of legs black, bases of fore femora narrowly and indistinctly obscure yellow; tibial spurs long, formula 1—2—2; claws small, simple. Wings with the ground cream yellow, prearcular field bright yellow, costal field, especially cell Sc, less brightly so; a vague brown pattern, including the stigma and clouds over the anterior cord, at midlength and near outer end of cell M, less evident on posterior cord and as washes in cells R and anals; veins beyond cord narrowly seamed with darker; a whitened spot before stigma, obliterative areas less evident; veins dark brown, yellowed in the brightened parts. Most longitudinal veins beyond cord with long macrotrichia, lacking on Rs, 1st A and all but outer ends of M and Cu; vein 2nd A with several trichia on all but base and apex; a single bristle on the prearcular anal vein. Venation: Rs about one-third longer than m-cu; R_{1+2} preserved; cell M_1 about twice its petiole; cell 1st M_2 long, narrower at outer end; M_{3+4} very short.

Abdomen black, including the hypopygium. Male hypopygium (Plate 2, fig. 14) with the tergite, *t*, transverse, posterior border with a large V-shaped emargination, lobes broad, with very few punctures. Ninth sternite extensive, with numerous punctures, including small marginal tubercles tipped with small setæ, the mesal angle prolonged into a slender rod. Outer dististyle, *d*, a dark colored blade, narrowed gradually to the obtuse tip, surface with moderately long black setæ; inner style simple, prolonged into a powerful cleaverlike beak; no developed lower beak or outer crest excepting a low darkened flange on posterior border; outer margin with very abundant pale setæ. Gonapophysis, *g*, appearing as a paddlelike blade. Eighth sternite unmodified.

Habitat.—Sikkim.

Holotype, male, Lakchmi Pokri, altitude 14,000 feet, in *Rhododendron* association, October 11, 1959 (*Schmid*). Paratopotype, male.

The reference of this unusually interesting fly to *Yamatotipula* is somewhat provisional but appears to be indicated by the venation and structure of the male gonapophyses. In its general appearance it is more like species of *Oreomyza* but the structure of the hypopygium, particularly the gonapophyses, would seem to bar it from this assignment. The fly is quite distinct from other regional small-sized species of *Tipula* in the

elongate antennæ of the male and in the general pattern of the legs and wings.

TIPULA (YAMATOTIPULA) HEXACANTHA sp. nov. Plate 2, fig. 15.

Size medium (wing of male 17 millimeters); general coloration of head and thorax light gray; frontal prolongation of head light yellow; antennæ short, outer flagellar segments blackened; femora and tibiæ yellow, tips narrowly blackened, claws of male bidentate; wings brownish yellow, restrictedly patterned; obliterative area before cord conspicuous; abdominal tergites brownish gray, lateral borders broadly light yellow; male hypopygium with posterior border of tergite blackened, produced into six small spinous points; inner dististyle complex, the outer basal lobe with an outer blade that bears about nine long curved reddish bristles.

Male.—Length, about 15 millimeters; wing, 17; antenna, about 2.4.

Frontal prolongation of head yellow, including the long nasus; palpi dark brown, terminal segment short, about twice as long as the penultimate. Antennæ short; scape brownish yellow, pedicel dark brown, proximal two flagellar segments black, their bases narrowly yellowed, outer segments uniformly blackened; basal swellings small, segments slightly exceeding the longest verticils. Head light gray, with indications of a capillary darker central vitta, more whitened on front; no vertical tubercle.

Pronotal scutum obscure yellow, narrowly darkened medially, gray on sides; scutellum and pretergites clear light yellow. Mesonotal præscutum light gray with four poorly indicated darker gray stripes, the central pair narrowly divided on anterior half by a darker line, humeral region yellow; scutum gray, each lobe with scarcely indicated darker gray areas, the oval anterior one more clearly indicated, posterior angles of lobes yellow; scutellum gray at base, the posterior half and the mediotergite more pinkish gray with a capillary darkened vitta, mediotergite laterally and the pleurotergite yellow, the katapleurotergite clearer yellow. Pleura light gray on anepisternum and sternopleurite, the remainder light yellow, including the dorsopleural membrane. Halteres infuscated. Legs with coxæ and trochanters yellow; femora and tibiæ yellow, tips narrowly brownish black, the amount subequal on all legs; tarsi black, proximal ends of basitarsi paler; claws bidentate, basal tooth small. Wings brownish yellow, cells C and Sc more saturated yellow; stigma pale

brown, inconspicuous, preceded by a more yellowed area in cell C; narrow dark seams on anterior cord and m-cu; a conspicuous continuous whitened obliterative area from before the stigma in cell R_1 extending into cell M_3, including also the outer ends of cells R and M; vague whitenings in bases of cells M_1 and 2nd M_2, cell R_5 not clearly brightened; veins dark brown, pale in the obliterative areas. Macrotrichia on longitudinal veins beyond the general level of origin of Rs, lacking on Rs, R_{1+2}, R_{2+3}, the veins comprising cell 1st M_2, and the broad bases of veins Cu_1, M_1 and M_3, virtually lacking on 1st A; 2nd A with strong trichia on more than outer half; trichia on prearcular anal vein and sparsely on m-cu. Venation: Petiole of cell M_1 subequal to or about two-thirds m; M_{3+4} from about one-third to one-half the basal section of M_{1+2}.

Abdominal tergites brownish gray, the lateral margins very broadly light yellow, basal rings restrictedly orange; posterior borders narrowly yellow, more evident on tergites four and five; sternites brown, yellowed laterally and at the incisures, more extensively so on outer segments; hypopygium chiefly obscure yellow. Male hypopygium (Plate 2, fig. 15) with the tergite, *t*, long, posterior border produced medially into a smooth blackened plate that bears two small teeth on either side of a small median lobe, together with a broader lateral tooth, a total of six acute points. Outer dististyle, *d*, pale, upper edge gently emarginate; inner style complex, both the beak and lower beak pale, the former cleaverlike, its dorsal crest low, fringed with setæ; outer basal lobe very large, modified about as illustrated; near outer end with a triangular blade that bears about nine long curved reddish bristles; sensory pits about seven in number in a single slightly broken row. Gonapophysis, *g*, appearing as a broad pale blade, broadest just beyond midlength. Ædeagus slender, intensely blackened.

Habitat.—Pakistan.

Holotype, male, Urak, May 28, 1954 (*Schmid*). Paratopotype, male, pinned with the type.

Tipula (*Yamatotipula*) *hexacantha* is quite distinct from the relatively few known regional members of the subgenus, including the widespread *T.* (*Y.*) *nova* Walker, which likewise has the outer basal lobe of the inner dististyle modified but in a quite different manner.

TIPULA (NOBILITIPULA) SPECULARIS sp. nov. Plate 2, fig. 16.

General coloration of thorax yellow, præscutum with three blue-gray stripes that are clearly delimited by black borders, each scutal lobe with a similar blue-gray area that is margined with black; antennal flagellum black; wings yellow, prearcular and costal fields brighter yellow; a restricted brown pattern, including the stigma, a broad seam over the cord and a cloud in the outer radial field; basal abdominal segments yellow, tergites trivittate with dark brown, outer segments black, more or less pruinose; male hypopygium with the tergite emarginate, the lobes with dense black setæ; outer dististyle arising from margin of the larger inner style; outer gonapophyses appearing as broad yellow blades with long conspicuous setæ.

Male.—Length, about 13 millimeters; wing, 13.5; antenna, about 4.3.

Frontal prolongation of head yellow, relatively short, about two-thirds the remainder of head; nasus short and stout, with black setæ; palpi with basal two segments brown, third paler brown, terminal segment brownish yellow, nearly equal in length to the remainder. Antennæ relatively long; scape light yellow, pedicel yellowish brown, flagellum black; flagellar segments with basal swellings very reduced, longest verticils unilaterally arranged on ventral face of segments, the longest slightly exceeding the segment. Head yellow, posterior vertex on either side behind the tumid vertical tubercle extensively pale brown; tubercles and median region of posterior vertex without setæ.

Pronotum yellow. Mesonotum light yellow, præscutum with three blue gray stripes that are clearly delimited by black borders, the lateral margins of the central stripe very broad on anterior half; scutum yellow, each lobe with a blue gray area that is almost encircled by black, broadest along mesal edge, at apex paling to brown; posterior sclerites of notum, including the pleurotergite, yellow, the katapleurotergite elevated into a spinoid tubercle; setæ of notum relatively sparse but very long, pale. Pleura light yellow, including the dorsopleural membrane; a small pale brown spot at dorsal angle of anepisternum. Halteres yellow, knob weakly lined with darker, including rows of black setæ. Legs with coxæ orange yellow, with very long yellow setæ; trochanters yellow; remainder of legs broken. Wings with the ground yellow, the prearcular field, with cells C and Sc, brighter yellow; stigma oval, brown; a broad paler

brown seam over the cord, with a similar brown wash in outer ends of cells R_2 and R_3; veins dark brown, yellowed in the brightened fields. Veins unusually glabrous, as in the subgenus, lacking on veins beyond cord, even on R_{4+5} where normally they are most persistent; a few trichia on base of vein R_{1+2}; basad of cord with trichia on C, Sc and R; squama naked. Venation: Rs arcuated; cell M_1 with petiole about two-thirds m; M_{3+4} subequal to basal section of M_{1+2}.

Basal five abdominal segments yellow, tergites trivittate with dark brown, central vitta lacking on basal tergite, interrupted at the incisures of the others, lateral stripe continuous; outer segments black, in places with a more or less evident light gray bloom. Male hypopygium (Plate 2, fig. 16) with the tergite, *t*, transverse, outer half narrowed into two broad subtriangular yellow lobes, separated by a V-shaped notch, the lobes with very abundant black setæ that are smaller and more numerous near the margins; cephalic half of sclerite glabrous. Outer dististyle, *d*, small, inserted at near midlength of lower margin of the larger inner style, broadest on outer half and here with relatively few but long black setæ, those at the base pale and more delicate; inner style with beak slender, lower beak broadly obtuse, both heavily blackened, outer margin of style with very long setæ; outer basal lobe large, subrectangular in outline, the angles, especially the outer one, more or less produced into points. Phallosome, *p*, with gonapophyses appearing as slender blackened spines and broadly flattened yellow blades, the latter at apex and along mesal margin provided with conspicuous yellow setæ, longer outwardly, shorter but very dense near base. Eighth sternite with margin truncate or very slightly convex, entire, with setæ over the outer three-fourths of plate, about evenly spaced throughout.

Habitat.—Sikkim.

Holotype, male, Namnasa, altitude 9,500 feet, July 12, 1959 (*Schmid*).

The present is the first record of occurrence of the subgenus *Nobilitipula* Alexander in India, the only other described Asiatic species being *T.* (*N.*) *fuiana* Alexander, of eastern China. The remaining species, including the subgenotype, occur in eastern North America. The present fly has the wing veins even more glabrous than in the other species.

TIPULA (ACUTIPULA) ECHO sp. nov. Plate 2, fig. 17.

Size relatively large (wing of male about 18 millimeters); mesonotal præscutum anteriorly and on sides broadly orange yellow, posterior part with four brown stripes, pleura grayish yellow; legs black; wings brown, conspicuously patterned with white and more restrictedly with darker brown; basal abdominal segments orange, tergites trivittate with dark brown, outer segments brownish black; male hypopygium with the tergal lobe yellow, virtually entire, the apex indistinctly trilobulate, with abundant black spicules; inner dististyle with a slender blackened blade immediately beyond the beak, the outer lobe large, margined with strong setæ; eighth sternite with sparse short setæ.

Male.—Length, about 15 to 16 millimeters; wing, 17.5 to 18; antenna, about 4.6 to 5.

Frontal prolongation of head chestnut brown to darker brown, still darker medially above, including the nasus; palpi black. Antennæ with scape and pedicel light yellow, proximal three or four flagellar segments vaguely bicolored, black at base, dark brown outwardly, the distal segments uniformly blackened; verticils subequal to or slightly longer than the segments. Head dark gray, anterior vertex and front more infuscated.

Pronotum uniformly orange. Mesonotal præscutum handsomely patterned, broadly orange yellow anteriorly and on sides, the posterior part of disk with four brown stripes, lateral interspaces gray, central vitta yellow; scutum light gray, each lobe with two darker gray areas; scutellum brownish orange, gray basally, parascutella brownish yellow; mediotergite blackish gray in front, light gray laterally and behind, pleurotergite obscure yellow, heavily gray pruinose, especially on the katapleurotergite. Pleura grayish yellow, dorsopleural region broadly orange yellow. Halteres blackened, base of stem narrowly reddish. Legs with coxæ and trochanters obscure yellow; remainder of legs black, femoral bases very narrowly yellow; claws of male bidentate. Wings with the ground brown, paler on basal third, prearcular field and cell Sc yellow; the darker brown areas include the stigma and a small mark in cell Cu; clearly defined white areas in cell M, becoming more yellowed behind; two areas in cell Cu and a narrow band beyond cord, including the bases of cells M_1, 2nd M_2, M_3 and M_4, together with outer end of R_5; a narrow entire obliterative area before cord, extending from before the stigma across the base of cell 1st M_2;

veins brown, yellowed in the prearcular field, whitened in the obliterative area. Veins very glabrous, including the outer medial branches; restricted trichia on R_{4+5}, M, M_{3+4}, and 2nd A; prearcular anal vein with numerous trichia. Venation: Petiole of cell M_1 subequal to m.

Abdomen with proximal five tergites orange, trivittate with dark brown, sublateral dark stripes narrower, lateral borders broadly buffy, sternites more yellowed, outer segments blackened, the pale tergal borders becoming narrower and finally obsolete on the eighth segment. Male hypopygium (Plate 2, fig. 17) with the tergite, *t*, darkened, the central area produced posteriorly into a broad depressed yellow lobe, gently widened outwardly, apex indistinctly trilobulate, the central lobule more pointed, all with small black spicules; lateral margins of sclerite with long setæ. Ninth sternite with a dense brush of setæ, as in *indra*. Outer dististyle, *d*, pale, about twice as long as broad, apex truncate; inner style distinctive, including a basal section and a loosely attached outer blade that includes the beak, an extensive outer lobe provided with stout setæ, and a slender blackened blade above the beak, the sensory area between the latter two; the smaller basal section apically with strong yellow setæ, including an outer lobe. Eighth sternite with apex shallowly emarginate, the low lobes with short sparse yellow setæ.

Habitat.—Sikkim.

Holotype, male, Shingba, altitude 10,400 feet, June 30, 1959 (*Schmid*). Paratopotypes, 2 males; paratype, 1 male, Lachung, altitude 8,610 feet, July 10, 1959 (*Schmid*); 2 males, Chachu, altitude 9,500 feet, in *Rhododendron* association, May 21, 1959 (*Schmid*).

This attractive species is quite distinct from other regional members of the subgenus. In its essentially entire lobe of the tergite of the hypopygium it is most like *Tipula* (*Acutipula*) *interrupta* Brunetti and *T.* (*A.*) *indra* Alexander, entirely different flies in other regards.

TIPULA (ACUTIPULA) HEMMINGSENIANA sp. nov. **Plate 2, fig. 18.**

Size small (wing of male about 13 millimeters); mesonotum chiefly darkened, pronotum and pleura yellow; mediotergite darkened basally, the broad posterior margins orange yellow; femora yellow, tips broadly black; wings light brown, prearcular field and cell Sc light yellow; cream colored areas in cell Cu and in bases of all outer medial cells; obliterative areas before

stigma and at cord whitened, very conspicuous; basal abdominal segments brownish yellow, tergites bordered laterally with brownish black, outer segments blackened; male hypopygium with the inner dististyle unusually simple, the outer lobe reduced to a small subcircular disk; eighth sternite trilobed.

Male.—Length, about 11 to 12 millimeters; wing, 12.5 to 13.5; antenna, about 3.3 to 3.5.

Frontal prolongation of head black above, including the short stout nasus, sides yellowish brown variegated with darker; palpi black. Antennæ with scape brownish black, pedicel light yellow, flagellum black, the extreme base of first segment yellow; basal enlargements of segments very small, verticils short, not quite one-half the segments. Head dark grayish brown, without a vertical tubercle.

Pronotum brownish yellow. Mesonotal præscutum with the disk virtually covered by four dark brown stripes that are vaguely bordered by blackish, the median lines darkened, lateral borders of præscutum yellow and orange; scutum dark brown, scutellum black, parascutella paler; mediotergite with central area chestnut brown, sides and posterior border broadly orange, light yellow pollinose; pleurotergite brownish gray above, katapleurotergite orange. Pleura testaceous yellow, propleura and dorsopleural membrane orange. Halteres with stem brown, knob brownish black. Legs with all coxæ light yellow, trochanters slightly darker; femora yellow, tips broadly black, more extensive on fore femora, slightly narrower on fore pair; tibiæ brown, tips slightly darker; basitarsi brown, succeeding segments black, terminal segment slightly paler; claws with a relatively short and broad tooth. Wings strongly suffused with light brown, prearcular field and cell Sc light yellow; stigma pale brown, inconspicuous; a brown cloud before midlength of cell Cu, preceded and followed by larger cream-colored areas, with similar pale spots in bases of all outer median cells; conspicuous more whitened obliterative areas before stigma, in outer end of cell R, and as a large spot in cell 1st M_2; veins brown, prearcular veins, with Sc and R, more yellowed. Macrotrichia on most longitudinal veins virtually back to the arculus, lacking on base of Cu_1; prearcular anal setæ abundant; squama with setæ. Venation: Rs a little longer than m-cu; petiole of cell M_1 subequal to m; M_{3+4} a little longer than basal section of M_{1+2}.

Basal five abdominal segments brownish yellow, tergites conspicuously bordered laterally with brownish black, outer four segments black, the outer dististyle white. Male hypopygium (Plate 2, fig. 18) with the tergite, *t*, strongly narrowed posteriorly, terminating in a median lobe that is shallowly divided at apex into two lobules, the apex with strong black spicules, more crowded outwardly; base of lobe produced into low shoulders. Outer dististyle, *d*, obtuse at tip, the length slightly less than three times the greatest width; inner style unusually simple, appearing as a compact blackened structure, its beak stout; outer apical angle with a small subcircular disk; face of style with a slender black spine, sensory pits conspicuous, lying distad of the spine. Gonapophysis, *g*, a flattened blade, dilated outwardly, tip oblique, outer apical angle obtuse. Eighth sternite, *8 s*, large, posterior half narrowed, apex trilobed, including a broad low central lobe provided with relatively few long setæ, and smaller lateral humps with fewer setæ; viewed from the side the median lobe is relatively prominent.

Habitat.—Sikkim.

Holotype, male, Namnasa, altitude 9,500 feet, July 12, 1959 (*Schmid*). Paratopotype, 1 male; paratypes, 5 males, Chachu, altitude 11,500 feet, June 29, 1959 (*Schmid*).

This unusually distinct fly is named for Dr. Axel M. Hemmingsen, distinguished student of crane-fly biology and ecology. The species is readily told from all other regional members of *Acutipula* by the small size, body coloration, and especially by the structure of the male hypopygium, including the inner dististyle and eighth sternite.

TIPULA (INDOTIPULA) MELACANTHA sp. nov. **Plate 1, fig. 2; Plate 2, fig. 19.**

Size unusually small (wing 11 millimeters or less); general coloration of thorax polished orange yellow, the pleura clearer yellow; antennal flagellum black, verticils short; femora brownish yellow, tips blackened; wings tinged with brown, stigma darker, Rs arcuated, a little longer than m-cu; abdominal tergites conspicuously patterned black and yellow, with a narrow black subterminal ring; male hypopygium with posterior border of tergite produced into two acute black spines, gonapophyses conspicuously setiferous.

Male.—Length, about 9 millimeters; wing, 10 to 10.5; antenna, about 3.1 to 3.5.

Female.—Length, about 12 millimeters; wing, 10.5 to 11; antenna, about 2.

Frontal prolongation of head yellow, nasus distinct; palpi brownish yellow. Antennæ with scape and pedicel yellow, first flagellar segment brownish yellow, remainder black; in male, segments moderately incised, verticils short, the longest scarcely one-half the segment; in female, antennal segments short. Head polished yellow, more or less darkened across the broad anterior vertex.

Pronotum light brown medially, paling to yellow on the sides. Mesonotum almost uniformly polished orange yellow, posterior sclerites and pleura clearer yellow. Halteres with stem obscure yellow, brighter basally, knob dark brown. Legs with coxæ and trochanters light yellow; femora brownish yellow, tips blackened; tibiæ and tarsi darker brown to black; claws of male with a single long tooth. Wings (Plate 1, fig. 2) tinged with brown, costal region slightly darker; stigma oval, darker brown; veins brown. Veins beyond general level of origin of Rs with long conspicuous trichia. Venation: Rs arcuated, a little longer than m-cu; R_{1+2} preserved; cell M_1 variable in depth, from about one and one-half to nearly three times its petiole; cell 2nd A narrow.

Abdominal segments bicolored, in male the tergites obscure yellow, posterior borders narrowly black, more expanded on posterior lateral angles; second segment with a black central spot; eighth segment blackened to form a narrow subterminal ring; sternites and hypopygium yellow; second segment very long; in female, the darkened tergal pattern more extensive, including a nearly complete central stripe and broader darkened subterminal ring. Ovipositor with cerci elongate, straight and slender. Male hypopygium (Plate 2, fig. 19) with posterior border of tergite, *t*, produced into two stout lobes, each terminating in a powerful black spine; ventral tergal armature about as figured, including paired outer blades, near base of each with a gently curved rod that bears a few blackened spicules at tip. Outer dististyle, *d*, simple, relatively narrow, broadest at base, the lower margin with strong black setæ; inner style unusually simple, the main body appearing as a simple flattened blade, the outer expanded head without major setæ but with a transverse flange; outer basal lobe about as long but narrower, the outer surface with strong erect yellow setæ, lower margin pale and membranous. Phallosome, *p*, including the short

ædeagus that is produced into a slender spine, gonapophyses appearing as broadly flattened oval blades with abundant setulæ and fewer long pale setæ, with further sclerotized infolding on lateral parts. Eighth sternite simple.

Habitat.—South India.

Holotype, male, Cherangode, Nilgiri Hills, altitude 3,500 feet, November 1950 (*Susai Nathan*). Allotopotype, female, pinned with types. Paratopotypes, males and females.

Tipula (*Indotipula*) *melacantha* is the smallest regional member of the subgenus so far discovered, in its hypopygial structure being entirely distinct from other species, such as *T.* (*I.*) *brachycantha* Alexander, *T.* (*I.*) *flavithorax* Brunetti, and *T.* (*I.*) *palnica* Edwards.

TIPULA (INDOTIPULA) PANDAVA sp. nov. Plate 2, fig. 20.

Size relatively large (wing of male about 15 millimeters); mesonotum chiefly reddish brown, more yellowed behind; wings yellowish brown, stigma darker, cell M_1 very deep, its petiole shorter than m; outer medial veins with macrotrichia; male hypopygium with tergal lobes black, rounded, widely separated; outer dististyle conspicuously dilated on basal half, inner style heavily blackened, the body very compact, outer basal lobe a powerful blackened rod.

Male.—Length, about 12.5 to 13.5 millimeters; wing, 14 to 15; antenna, about 3.8 to 4.

Frontal prolongation of head above light yellow, the sides brown; nasus elongate; palpi brown, terminal segment brownish black. Antennæ with scape obscure yellow, pedicel light yellow, flagellum black; flagellar segments slender, slightly exceeding the longest verticils. Head with front light yellow, more obscure yellow surrounding the antennal bases; posterior part of head brownish gray, with a ⊥-shaped darker pattern an anterior vertex, the stem extended cephalad between the antennal bases, terminating in two small dark brown spots on the front.

Cervical region and pronotum weakly infuscated above, yellow on sides. Mesonotal præscutum with disk chiefly covered by four stripes, the narrow intermediate pair obscure yellow, bordered by reddish brown, the sublateral stripes more solidly darkened, lateral margins broadly light yellow; posterior sclerites of notum obscure orange, clearer behind, parascutella a little darker; postnotum glabrous. Pleura brownish yellow in front, becoming clearer orange yellow behind. Halteres with

stem pale brown, knob darker, tip narrowly pale. Legs with coxæ yellow, fore pair weakly darkened in front; trochanters yellow; femora obscure yellow basally, passing into brown, tips brownish black; tibiæ and tarsi brownish black; claws of male bidentate, basal tooth shorter and stouter. Wings yellowish brown, base and costal region more yellowed, stigma darker brown; obliterative areas before stigma and across cell 1st M_2 small; veins dark brown. Macrotrichia of veins beyond cord conspicuous, on outer medial veins including complete series on M_1, M_2 and all but the base of M_3, on M_4, on outer third; 1st A with a few trichia near arculus, 2nd A glabrous; abundant trichia on prearcular anal vein. Venation: Cell M_1 deep to very deep, its petiole about one-third to one-half m.

Abdomen at base brownish yellow, outer segments darkened, hypopygium brownish black. Male hypopygium (Plate 2, fig. 20) with the tergite, *t*, transverse, broadest across base, narrowed outwardly, terminating in two blackened lobes separated by a broad shallow emargination, fringed with long setæ, with a further small median lobule; major lobes obtusely rounded at tips, smooth at summit, the bases and inner faces with small black spicules. Ninth sternite, *9s*, with an oval lobe covered with very long setæ. Basistyle, *b*, on outer face near apex with conspicuous long yellow setæ. Outer dististyle, *d*, yellow, elongate, broadest on basal half before midlength, distal end very slender, outer margin fringed with long setæ; inner style distinctive, the body a subrectangular blackened mass, beak very obtuse, lower beak small, pointed; outer basal lobe almost separated from body of style, appearing as a slender gently curved blackened rod from a more dilated base, apex of rod slightly expanded, its outer angle produced into a spine. Gonapophysis, *g*, appearing as a flattened paddlelike blade. Eighth sternite with margin convexly rounded.

Habitat.—Sikkim.

Holotype, male, Lathong, altitude 6,560 feet, July 26, 1959 (*Schmid*). Paratopotype, 1 male; paratype, male, Selep, altitude 7,000 feet, July 27, 1959 (*Schmid*).

Tipula (*Indotipula*) *pandava* agrees rather closely with Edwards, redescription of the type of *T.* (*I.*) *divisa* Brunetti,[1] but disagrees entirely with Brunetti's original description of the hypopygial dististyles, and in other features that make it im-

[1] Stylops 1 (1932) 236-237.

possible to reconcile the two flies. The inner dististyle of the present fly is entirely different from that of other generally similar described species.

TIPULA (INDOTIPULA) PROLATA sp. nov. Plate 2, fig. 21.

General coloration buffy yellow, præscutum with four pale brown stripes that are narrowly bordered by cinnamon brown; wings weakly tinged with brownish yellow, base and costal field clearer yellow, stigma medium brown; outer abdominal segments infuscated; male hypopygium with tergal lobes spiculose; outer dististyle broad, terminating in a small lobule; beak of inner style long and straight, outer crest with a compact group of five strong reddish bristles, outer basal lobe large and complex; eighth sternite large, central part pale membranous, with sparse setæ.

Male.—Length, about 11 millimeters; wing, 12.5.

Frontal prolongation of head brownish yellow; nasus distinct; first segment of palpus brownish yellow, the remainder darker. Antennæ with scape and pedicel obscure yellow; flagellum broken. Head black, sparsely pruinose, paler on occipital region; anterior vertex very broad, without a tubercle.

Cervical region and pronotum buffy yellow, scutum weakly infuscated medially. Mesonotal præscutum buffy laterally, disk with four pale brown stripes that are delimited by narrow more cinnamon-brown borders, posterior interspaces obscure yellow; posterior sclerites of notum brownish yellow, mediotergite broadly more reddened behind; mesonotum unusually glabrous, with very sparse pale setæ on the præscutal interspaces. Pleura buffy yellow, dorsopleural membrane yellow. Halteres with stem brownish yellow, base clearer yellow, knob dark brown. Legs with coxæ buffy yellow, trochanters clearer yellow; remainder of legs broken. Wings weakly tinged with brownish yellow, prearcular and costal fields, together with the narrow cell Cu_1, clear yellow; stigma oval, medium brown; restricted more whitened obliterative areas before stigma and across cell 1st M_2; veins pale brown, more yellowed in the brightened fields. Macrotrichia on veins R_{2+3}, R_2, R_3, R_{4+5}, M_1 and M_2, more sparse on outer end of M_3; virtually lacking or very few on M_4 and distal section of Cu_1; very sparse and scattered trichia on Rs, M and Cu, lacking on anal veins; proximal end of 1st A and prearcular anal vein with trichia; squama naked. Venation: Petiole of cell M_1 nearly twice m; M_{3+4} subequal to basal

section of M_{1+2}; m-cu just beyond base of M_4; cell 2nd A moderately wide, broadest just beyond midlength.

Basal abdominal tergites infuscated, lateral borders yellow, broadest on basal two segments; proximal sternites yellow; outer segments chiefly darkened, especially the tergites; eighth sternite with about six obscure yellow spots. Male hypopygium (Plate 3, fig. 21) with the tergite, *t*, long, narrowed posteriorly, terminating in two triangular lobes that are separated by a deep U-shaped notch, the lobes with abundant blackened spicules, those at apex and on inner margin larger. Outer dististyle, *d*, broad, its length about two and one-half times the greatest breadth which is beyond midlength, apex constricted to form a small oval lobule clothed with delicate setæ; inner style with the beak unusually long and straight, glabrous, lower beak short and broad, darkened, surface microscopically tuberculate; outer crest of style with a compact group of five strong reddish bristles that are produced into hairlike points; outer basal lobe large and complex, its area only a little less than the remainder of style. Ædeagus simple, produced into a slender blackened point. Eighth sternite very large, narrowed posteriorly, the central part with pale membrane, the setæ only on sides of the membranous part, apex truncate.

Habitat.—Pakistan.

Holotype, male, Kawai, altitude 4,800 feet, June 24, 1953 (*Schmid*).

The nearest ally is *Tipula* (*Indotipula*) *simlensis* Edwards, which is quite distinct in the hypopygial structure, including especially both dististyles and the eighth sternite. The present fly lacks the remarkable setal adornment of the eighth sternite found in *simlensis*.

TIPULA (VESTIPLEX) EURYDICE sp. nov. Plate 3, fig. 23.

Allied to *inæquidentata;* mesonotal præscutum light gray with four brownish gray stripes that are partly bordered by brown; pleura gray, posterior sclerites clear yellow; antennæ black, basal three segments light yellow; legs black, femora with a very conspicuous yellow subterminal ring; wings creamy yellow with a pale brown pattern, the prearcular and costal fields bright saturated yellow; basal four abdominal segments orange yellow, outer segments black; male hypopygium with the dorsal tergal rods slender, ventral armature black, bispinous; appendage of ninth sternite long, dilated outwardly; basistyle with a black-

ened lobe; inner dististyle with beak slender, blackened, both the dorsal and posterior lobes conspicuous; ædeagus without a lateral shoulder.

Male.—Length, about 13 to 14 millimeters; wing, 15 to 17; antenna, about 4.8 to 5.

Frontal prolongation of head above light yellow, including the nasus, weakly infuscated on sides and beneath; palpi black, incisures paler. Antennæ relatively long; basal three segments light yellow, fourth light brown, its base darker, outer segments black, longer than their verticils; basal enlargements of segments very small. Head reddish, heavily light yellow pollinose, with a capillary pale brown central line from the small entire vertical tubercle.

Pronotum gray, vaguely patterned with pale brown. Mesonotal præscutum light gray, with four clearly differentiated dark brownish gray stripes that are margined with darker brown, most distinct on outer margins of intermediate stripes and inner borders of the lateral pair, humeral region restrictedly dark brown; scutum light gray, each lobe with two almost confluent brown areas; scutellum brownish gray, parascutella paler; mediotergite yellow, vaguely darkened at base and on central part, pleurotergite brownish yellow above, more yellow pollinose on the katapleurotergite. Pleura gray, patterned with grayish yellow on the dorsal sternopleurite, posterior sclerites clear yellow; dorsopleural membrane buffy yellow. Halteres with stem yellow, knob dark brown basally, apex broadly obscure yellow. Legs with coxæ and trochanters yellowed; femora black, bases narrowly yellow, with a broader very distinct yellow subterminal ring; tibiæ and tarsi black; claws of male toothed. Wings with the ground creamy yellow, the prearcular and costal fields bright saturated yellow; a pale brown pattern, subequal in extent to the ground areas except on basal third of wing where the yellow bands are broad; obliterative areas before stigma and across cell 1st M_2 more whitened; distal half of cell R_5 yellowed; veins brownish yellow, clear yellow in the brightened fields. Outer longitudinal veins with macrotrichia, lacking on Rs, more than the basal half of M, most of Cu_1 and 1st A; 2nd A with trichia on outer two-thirds; no prearcular anal trichia. Venation: Vein R_3 gently arcuated; Rs about one-half longer than m-cu.

Basal four abdominal segments orange yellow, tergites slightly patterned, most evident as vague sublateral lines and a cen-

tral darkening at base of abdomen; remainder of abdomen black, lateral tergal borders of segments five and six narrowly pale. Male hypopygium (Plate 3, fig. 23) with the tergite, *t*, distinctive, including a paler brownish black dorsal plate, each lobe extended into a slender parallel-sided blade; ventral armature heavily blackened, bifid, including an acute black mesal spine and a stouter lateral black rod, its tip microscopically toothed or bidentate. Appendage of ninth sternite, *9s*, a strong rod, beyond base gradually dilated, apex obliquely truncate, base of blade with a sparse fringe of long yellow setæ, apex with fewer scattered bristles. Basistyle, *b*, produced into a blackened blade, its apex obtuse. Outer dististyle, *d*, relatively narrow, darkened, with long black setæ; inner style with beak black, slender, widened basally into a broad plate; dorsal crest short but unusually high, with long erect setæ; posterior lobe broadly rounded. Ædeagus, *a*, pointed at apex, shaped about as figured, lacking the lateral shoulders found in *inæquidentata*.

Habitat.—Sikkim.

Holotype, male, Chateng, altitude 8,700 feet, May 22, 1959 (*Schmid*). Paratopotype, male.

The most similar described species is *Tipula* (*Vestiplex*) *inæquidentata* Alexander, of the eastern Himalayas, which differs especially in details of the male hypopygium, particularly the tergite, appendage of the ninth sternite, the inner dististyle and the ædeagus.

TIPULA (VESTIPLEX) KUMAONENSIS sp. nov.

Closely allied to *avicularia*, differing in the large size and in details of structure of the hypopygium, particularly the inner dististyle and appendage of the ninth sternite.

Male.—Length, about 15 to 17 millimeters; wing, 19 to 21; antenna, about 3.8 to 4.

Frontal prolongation of head brownish yellow, gray above, nasus distinct; palpi brownish black, outer segments black. Antennæ relatively short; scape and pedicel yellow, flagellum black. Head buffy yellow, more infuscated medially.

Pronotum gray, patterned with brown. Mesonotal præscutum light gray laterally, disk chiefly covered by three brownish gray stripes that are narrowly bordered by darker, especially the lateral margins of the central vitta and inner edge of the laterals; central vitta vaguely divided by a darkened line, posterior interspaces brownish gray; scutal lobes dark gray, inner part

more infuscated; central region of scutum and scutellum light gray; mediotergite more yellowish gray, the latter two areas with a distinct dark brown central line; pleurotergite gray, katapleurotergite whitened. Pleura gray, dorsopleural region brown. Halteres with stem reddish brown at base, darker outwardly, knob dark brown. Legs with coxæ brown, gray pruinose, posterior pair paler; trochanters obscure yellow; femora black with a conspicuous subterminal yellow ring; tibiæ and tarsi black; claws of male toothed. Wings broad, light brown, patterned with creamy yellow areas; stigma and a large cloud over anterior cord darker brown; the pale marks include a narrow poststigmal band extending backward into the base of cell M_3; basad of cord the dark and pale areas zigzag and are approximately equal in area.

Abdomen with proximal four segments orange, outer segments, including the hypopygium, black; a broad black central tergal stripe, scarcely interrupted at posterior borders of segments. Male hypopygium much as in *avicularia*, differing in details, especially of the dististyles and appendage of the ninth sternite. Ninth tergite with a shallow but conspicuous V-shaped notch, the margin with abundant recurved black setæ; no ventral armature. Appendage of ninth sternite nearly parallel-sided, outwardly narrowed to the acute tip, with unusually long and abundant yellow setæ, the appendage not dilated outwardly and not appearing like a bird's head, as in *avicularia*, the structure united with the appendage of the basistyle. Basistyle with the apical lobe broadly rounded at tip, with a small lateral point. Outer dististyle elongate, widened outwardly; outer margin of inner style with very long and conspicuous yellow setæ.

Habitat.—India (Kumaon).

Holotype, male, Gangrea, Pauri Garhwal, altitude 7,500 to 10,000 feet, June 12, 1958 (*Schmid*). Paratopotypes, 3 males, June 12 to 14, 1958.

I have a paratype of *Tipula* (*Vestiplex*) avicularia Edwards and consider the present fly as being distinct though very closely allied.

TIPULA (VESTIPLEX) RHIMMA sp. nov. Plate 3, fig. 22.

Size medium (wing of male 14.5 millimeters); mesonotum yellow pollinose, præscutum with four brown stripes, posterior sclerites and pleura patterned with brown; basal antennal segments yellow, flagellum black; wings narrow, light brown, ex-

tensively variegated with creamy yellow areas; basal abdominal tergites yellow, trivittate with brown, outer segments darkened; male hypopygium with lower lobes of tergite very large; appendage of ninth sternite a broad yellow blade with many setæ; outer dististyle boomerang-shaped, apex triangularly dilated, inner style with beak slender, blackened.

Male.—Length, about 12 millimeters; wing, 14.5; antenna, about 3.5.

Frontal prolongation of head yellow, including the long nasus, sides with a narrow brown line; palpi with basal segment yellow, remainder dark brown, terminal segment about equal in length to the preceding two combined. Antennæ with scape and pedicel light yellow, first flagellar segment light brown, remainder black; flagellar segments with small basal enlargements, verticils long, subequal to the segments. Head yellow, darker behind on the posterior vertex; a narrow light brown central vitta on vertex, extending from center of the low entire tubercle to the occiput.

Pronotum obscure yellow, with three brown stripes. Mesonotal præscutum light yellow with four brown stripes, the intermediate pair separated by a capillary ground line, more evident behind; scutal lobes yellow, restrictedly patterned with brown; scutellum and mediotergite yellow with an indistinct brown central line; vestiture of notum, especially of the mediotergite, yellow, conspicuous. Pleura and pleurotergite yellow, propleura, anepisternum, ventral sternopleurite, ventral pteropleurite, and meron more darkened. Halteres with stem reddish brown, knob darker brown, apex paler. Legs with coxæ and trochanters yellow; femora dark brown, base and a broader subterminal ring light yellow; tibiæ and tarsi dark brown; claws of male toothed. Wings narrow, light brown, extensively patterned with yellow, prearcular and costal fields deeper yellow; stigma brownish yellow; basad of the cord the yellow areas very extensive, including much of cells R, M, Cu, and base of 1st A; cell 2nd A with two yellow areas; beyond cord a conspicuous brightening extending from costa backward, barely entering cell R_5; obliterative areas before stigma and across cell 1st M_2 a trifle more whitened; veins brown, yellowed in the brightened fields. Macrotrichia on veins beyond cord, lacking on the pale outer half of R_{1+2}; sparse trichia on outer ends of M, basal section of Cu_1 and 1st A, more extensive on 2nd A, lacking on Rs; no prearcular anal trichia. Venation: Rs about two and one-half times

m-cu, the latter before the fork of M_{3+4}; petiole of cell M_1 slightly longer than m.

Basal abdominal tergites yellowed, trivittate with brown, outer segments more extensively darkened; basal sternites reddish yellow, outer segments dark brown. Male hypopygium (Plate 3, fig. 22) with the tergite, *t*, distinctive; dorsal lobes relatively small, pale, tips rounded, separated by a broad U-shaped notch; lower blades much larger, arising far laterad, the narrowed beaklike part slightly upturned, almost meeting at the midline. Appendage of ninth sternite, *9s*, a broad yellow blade, the slightly constricted apex obtuse, with many setæ, with further larger marginal bristles. Outer dististyle, *d*, yellow throughout, shaped like a narrow boomerang, the apex triangularly dilated, the setæ abundant, short and pale; inner style with beak slender, blackened, lower beak dilated into an oval yellow blade. Ædeagus, *a*, small, the apex subtruncate, the angles slightly produced.

Habitat.—Sikkim.

Holotype, male, Mangalbarey, altitude 2,800 feet, April 30, 1959 (*Schmid*).

Tipula (*Vestiplex*) *rhimma* is still another of the small to medium-sized members of the subgenus that are allied to *T.* (*V.*) *ravana* Alexander. It is entirely distinct in the structure of the male hypopygium, including especially the tergite, appendage of the ninth sternite, and outer dististyle.

TIPULA (VESTIPLEX) SIDDARTHA sp. nov. **Plate 3, fig. 24.**

Size small (wing of male 14.5 millimeters); general coloration of thorax yellow, præscutum with four light brown stripes, scutellum and mediotergite with a central dark line, dorsal pleurites darkened; antennæ black, scape and pedicel yellow; femora brown with an obscure yellow subterminal ring, claws of male toothed; wings brown, variegated by darker brown and cream colored areas; basal abdominal segments brownish yellow, tergites with three darker stripes, outer segments uniformly darkened; male hypopygium with upper tergal lobes flattened, obtuse, lower lobes narrow, blackened; appendage of ninth sternite a flattened yellow blade, the obtuse tip with about seven long yellow setæ; basistyle unarmed; inner dististyle with beak slender, blackened, lower beak yellow, scooplike; apex of ædeagus bidentate.

Male.—Length, about 13.5 millimeters; wing, 14.5; antenna, about 4.4.

Frontal prolongation of head above light yellow, including the long nasus, sides darker; palpi yellowish brown. Antennæ relatively long; scape and pedicel yellow, flagellum black, the first segment a little paler; basal enlargements of segments scarcely developed, longest verticils subequal to the segments. Head buffy yellow; vertical tubercle entire, clearer yellow; a faint capillary brown central line from behind the tubercle almost reaching the occipital border.

Pronotum buffy yellow, patterned with brown. Mesonotal præscutum yellow pollinose, with four light brown stripes, the intermediate pair darkened on internal margins to form a dusky central line; scutum yellow, each lobe with two separate light brown stripes; scutellum and mediotergite yellow with a conspicuous central dark brown line, interrupted posteriorly. Pleura yellow, cervical region, propleura and anterior part of anepisternum patterned with dark brown. Halteres with stem yellow, knob brownish black, the apex paling to obscure yellow. Legs with coxæ and trochanters yellow; femora brown, tips blackened, preceded by a narrow obscure yellow subterminal ring; tibiæ and tarsi black; claws of male setiferous, with an acute basal spine, outer half blackened. Wings with the ground brown, variegated by darker brown and cream-colored areas, prearcular field yellow; costal cell yellow on central part, base more darkened; large dark areas additional to the stigma include a postarcular mark, origin of Rs and anterior cord; the pale pattern includes a broad postarcular brightening in cells R and M, with smaller outer areas, marks before and beyond stigma, the latter a short band extending from costa to cell 1st M_2; cells Cu and anals variegated, including two pale areas in cell 2nd A; no marginal brightenings in outer radial or medial fields; veins dark brown, more yellowed in the brightened fields. Veins beyond general level of origin of Rs with abundant trichia, lacking basally on Rs and M; an almost complete series on 2nd A, 1st A with two or three near tip. Venation: Rs long, straight, nearly twice m-cu; petiole of cell M_1 not quite twice m; m-cu shortly before fork of M_{3+4}.

Abdomen brownish yellow basally, the tergites darker medially and sublaterally, outer segments darker, especially the blackened eighth and ninth; appendages yellow. Male hypopygium (Plate 3, fig. 24) with upper lobes of tergite, *t*, flattened,

obtusely rounded, separated by a deep median split; lower lobes slender, their blackened tips weakly emarginate or lobed, the inner lobule scabrous. Appendage of ninth sternite, *9s*, a flattened yellow blade, slightly dilated at outer end, apex obtuse, on lower margin below tip with about seven long yellow setæ. Basistyle unarmed. Outer dististyle, *d*, narrow, broadest at near two-thirds the length, narrowed outwardly; inner style with the beak slender, blackened, lower beak yellow, scooplike; dorsal crest long and low, glabrous, along its base with a linear series of eight circular punctures, each with a short stout pale spine. Ædeagus, *a*, yellow, broad at base, apex with two acute spines separated by a shallow emargination.

Habitat.—Sikkim.

Holotype, male, Rapham, altitude 5,250 feet, April 2, 1959 (*Schmid*).

The most similar regional species are *Tipula* (*Vestiplex*) *halteroptera* Alexander and *T.* (*V.*) *ravana* Alexander, readily told from the present fly by the structural characters, including the simple claws of the first named species. All structures of the hypopygium of *ravana* are quite distinct. The circular spine-bearing punctures on the inner dististyle, as described for the present fly, are likewise found in *ravana* but are only three in number, lying far back.

TIPULA (OREOMYZA) LAETABUNDA sp. nov. Plate 1, fig. 3; Plate 3, fig. 25.

Size medium (wing of male over 10 millimeters); general coloration of mesonotum yellow, præscutum with four more brownish stripes, the intermediate pair confluent in front; antennæ black, the scape, pedicel and base of first flagellar segment yellow; legs black, claws of male simple; wings yellowish white, extensively patterned with brown, arcular area and cell Sc light yellow; R_{1+2} atrophied, m-cu near outer end of M_{3+4}; basal abdominal segments yellow, beyond the fifth brownish black; male hypopygium with the tergal lobes rounded, median notch small; outer basal lobe of inner dististyle rounded.

Male.—Length, about 9.5 millimeters; wing, 10.6; antenna, about 3.5.

Frontal prolongation of head heavily yellow pollinose, especially above; nasus conspicuous; palpi black. Antennæ with scape, pedicel and more than the proximal half of first flagellar segment yellow, remainder of organ black; flagellar segments not incised, slightly stouter at base, exceeding the verticils,

terminal segment very small. Head olive, slightly more grayish behind; vertex with a very delicate darker line; vertical tubercle low.

Pronotum yellow, slightly variegated with darker. Mesonotal præscutum with the ground yellow pollinose, with four inconspicuous more brownish stripes, the intermediate pair confluent in front, lateral stripes broader; posterior sclerites of notum olive yellow, scutal lobes with two brown areas, the posterior one larger; central part of mediotergite slightly darker. Pleura olive yellow, variegated with large gray areas on anepisternum, ventral sternopleurite and meron; dorsopleural membrane brownish yellow. Halteres with stem yellowed, knob dark brown. Legs with coxæ olive yellow; trochanters yellow; remainder of legs black, femoral bases very narrowly yellowed; claws simple. Wings (Plate 1, fig. 3) with the ground yellowish white, with an extensive brown pattern that exceeds the ground areas, cell Sc and region of arculus clear light yellow; the major ground areas include two in cells R and 1st A, one in M, most of Cu and an extensive band beyond cord, extending from C subbasally across cells R_3 and R_5, widened posteriorly in cells 1st M_2, 2nd M_2 and M_3; veins brown, yellowed in the brightened areas. Macrotrichia on most longitudinal veins beyond cord, lacking on Rs and 2nd A, present on outer ends of M, Cu_1 and 1st A. Venation: Rs long, about three times m-cu, at fork shirred or deflected downward; R_{1+2} atrophied; cell M_1 about twice its petiole; cell 1st M_2 small, pentagonal; M_{3+4} long, with m-cu shortly before its fork; cell M_4 widest at margin.

Abdomen with basal five segments yellow, remainder dark brown to brownish black. Male hypopygium (Plate 4, fig. 25) with the tergite, *t*, large, posterior border with two broad yellow rounded lobes, median area with a microscopic emargination, cephalad of this with a dorsal furrow; setæ of lobes relatively small, especially outwardly, those of the disk larger. Outer dististyle, *d*, flattened, apex obtuse; inner style with beak relatively narrow, tip obtuse, lower beak much broader, surface with parallel darkened lines; outer basal lobe a flattened blade, its margin obtuse. Phallosome, *p*, broad, including four short sclerotized points, the outer pair directed caudad, the lower ones cephalad. Margin of eighth sternite unmodified.

Habitat.—Sikkim.

Holotype, male, Namnasa, altitude 9,500 feet, July 13, 1959 (*Schmid*).

The nearest regional ally is *Tipula* (*Oreomyza*) *camillerii* Alexander, of the eastern Himalayas, which differs in the still smaller size, pattern of the wings, and in details of the male hypopygium.

TIPULA (OREOMYZA) GUTTULIFERA sp. nov. **Plate 3, fig. 26.**

Belongs to the *marmorata* (*fragilis*) group; mesonotal præscutum gray with four brownish black stripes, pleura patterned gray and brownish black; antennæ of male long, approximately one-half the body, basal segments yellow, flagellum black; legs brownish black, femoral bases narrowly yellowed; wings brown, conspicuously patterned with white and creamy spots and droplets; abdomen brownish black; male hypopygium with tergal lobes very slender, each with two setæ; basistyle not blackened on mesal face; outer dististyle slightly dilated but not blackened at base; inner style broad, beak small; eighth sternite entirely unmodified.

Male.—Length, about 12.5 to 13 millimeters; wings, 14 to 14.5; antenna, about 6.8 to 7.

Frontal prolongation of head black, faintly pruinose near base, nasus distinct; palpi black. Antennæ of male elongate, approximately one-half the body; scape yellow, restrictedly darkened at base, pedicel light yellow, flagellum black; flagellar segments beyond the first with small oval basal enlargements, verticils much shorter than the segments. Head above brown, slightly more darkened medially; front and anterior vertex on sides of the low vertical tubercle light gray.

Pronotal scutum variegated gray and black, central region of scutellum testaceous. Mesonotal præscutum with the ground gray, with four brownish black stripes, the intermediate pair narrowly separated by an obscure central line, anterior and lateral borders more narrowly darkened; scutum brownish gray, each lobe with two conspicuous dark brown areas; scutellum brown, paler laterally, parascutella testaceous brown; mediotergite brownish gray. Pleura gray, variegated with brownish black on anepisternum, ventral sternopleurite and meron, clearer gray behind; dorsopleural membrane dark brown. Halteres long, stem yellow, knob brownish black. Legs with coxæ gray; trochanters yellow; femora brownish black, bases narrowly yellowed; tibiæ brownish black, tarsi black; claws small, simple. Wings with the ground brown, conspicuously patterned with white and creamy spots and droplets; stigma and area over an-

terior cord slightly darker brown; whitened spots in outer end of cell R, base of 1st M_2, two marginal areas in cell 1st A, one in 2nd A; more diffuse whitened marks in bases of cells R, M and anals; cream-colored spots present in most cells both before and beyond the cord, including prestigmal and poststigmal brightenings; all outer cells with creamy central spots; basad of cord the areas include one in cell R, two in each of cells M and Cu, and one at basal third of 1st A; prearcular field chiefly pale yellow; cells C and Sc uniformly brown; veins brown, anterior prearcular veins yellow. Veins beyond general level of origin of Rs with strong trichia, including virtually all of R and M and outer end of 1st A; lacking on 2nd A, including the prearcular sections, and in cases, the basal section of Cu_1. Venation: Petiole of cell M_1 longer than m; M_{3+4} short to very short, less than r-m.

Abdomen brownish black, basal tergites slightly pruinose, posterior borders of segments very narrowly pale. Male hypopygium (Plate 3, fig. 26) with the tergal lobes, *t*, very slender, lying almost parallel to one another, each with two widely separated setæ on inner edge. Basistyle with mesal margin only weakly darkened. Outer dististyle, *d*, stout, base dilated but not blackened, obtuse; setæ sparse, longer near base, marginal and outer setæ small and weak; inner style unusually broad, beak small, blackened; dorsal crest high; region of outer basal lobe a low darkened flange with several strong setæ; longer but pale setæ on disk at base of dorsal crest. Eighth sternite with posterior border truncate, entirely unmodified, with only a few relatively short setæ.

Habitat.—Sikkim.

Holotype, male, Gopetam, altitude 12,200 feet, in *Rhododendron* association, October 10, 1959 (*Schmid*). Paratopotype, male, pinned with type.

Tipula (*Oreomyza*) *guttulifera* is entirely distinct from all other regional members of the group that have the wings more or less patterned with light and dark, including *T.* (*O.*) *baltistanica* Alexander and *T.* (*O.*) *letifera* Alexander. The long antennæ and conspicuous pattern of the wings provide noteworthy characters.

TIPULA (OREOMYZA) SORDIDIPES sp. nov. Plate 3, fig. 27.

Belongs to the *marmorata* (*fragilis*) group; general coloration of thorax gray, præscutum with four dark brown stripes;

legs black, femoral bases narrowly yellow; wings weakly tinged with brown, vaguely patterned with darker; abdomen dark brown, sparsely pruinose, the central tergites more or less yellowed, sternites uniformly darkened.

Male.—Length, about 9.5 to 11 millimeters; wing, 11 to 12; antenna, about 3.8 to 4.

Female.—Length, about 11 millimeters; wing, 8.5.

Frontal prolongation of head brownish gray, nasus elongate, with yellow setæ; palpi black. Antennæ moderately long, as shown by the measurements; scape and pedicel obscure yellow, flagellum black; flagellar segments slightly incised, basal enlargements conspicuous; segments exceeding the verticils, with a further dense white pubescence. Head gray, center of vertex extensively light brown.

Pronotum gray, scutum vaguely patterned with brown. Mesonotal præscutum gray, with four dark-brown stripes, the intermediate pair separated behind, confluent anteriorly, their anterior ends with gray centers, lateral stripes solidly darkened; pseudosutural foveæ black, punctiform; scutum gray, each lobe with two confluent dark-brown areas; posterior sclerites clear light gray. Pleura light-gray, slightly patterned on ventral anepisternum and ventral sternopleurite with darker gray. Halteres with stem dirty yellow, knob dark-brown. Legs with coxæ light-gray; trochanters brown; remainder of legs black, bases of fore femora, and in cases the middle pair, narrowly obscure yellow; claws simple. Wings weakly tinged with brownish yellow, stigma and a vague wash in cells R_2 and R_3 pale brown; veins light brown. Macrotrichia of veins beyond level of origin of Rs abundant, lacking on about the basal fourth of M, approximately the basal half of Cu_1 and 1st A, and basal two-thirds of 2nd A; no trichia on prearcular anal vein. Venation: Rs approximately one-third to one-half longer than m-cu, the latter on M_4 leaving a basal section that is a little shorter than M_{3+4}.

Abdomen dark brown, sparsely gray pruinose, central part of tergites two to four more yellowed, especially the posterior border of the last, in cases even more extensive, reaching the seventh tergite or extreme base of the eighth; appendages of hypopygium reddened. Male hypopygium (Plate 3, fig. 27) with the tergite, *t*, shallowly emarginate, the border with small black spicules. Blackened lobe on mesal face of basistyle with abundant microscopic tubercles. Outer dististyle, *d*, widened across basal half,

the dilated margin narrowly blackened; inner style with outer part relatively narrow, tapering to the narrowly obtuse apex. Eighth sternite with posterior margin gently convex, with a few relatively long black setæ.

Habitat.—Kashmir.

Holotype, male, Chotta Deosai, altitude 12,675 feet, in marsh, September 12, 1953 (*Schmid*). Allotopotype, female, pinned with type. Paratopotypes, males and females.

The closest regional ally is *Tipula* (*Oreomyza*) *venerabilis* Alexander, likewise from Kashmir, which is well distinguished by the coloration of the body and legs. In this latter fly the fore femora are chiefly blackened but the other legs are brownish yellow, the femoral tips narrowly blackened, while the abdomen, including both tergites and sternites, are extensively yellowed.

TIPULA (LUNATIPULA) STYLOSTENA sp. nov. **Plate 3, fig. 28.**

Allied to *marmoratipennis;* mesonotum gray, præscutum with four conspicuous brownish gray stripes that are narrowly bordered by dark brown; wings yellow, conspicuously tessellated with brown; macrotrichia of veins relatively sparse; abdomen orange, outer segments blackened, in male the terminal segments telescoped within the preceding ones; outer dististyle very narrow, terminating in about four blackened spinoid setæ; beak of inner style slender.

Male.—Length, about 15 to 16 millimeters; wing, 18.5 to 21; antenna, about 3.5 to 3.8.

Female.—Length, about 20 to 21 millimeters; wing, 21 to 22.

Frontal prolongation of head above grayish yellow, including the nasus, sides dark brown; palpi brown, terminal segment yellowed. Antennæ relatively short; scape and pedicel yellow, flagellum dark-brown, in some specimens (Badrinath paratype) more bicolored, the tips of the flagellar segments yellowed; segments weakly incised, shorter than their verticils. Head yellowish brown, clearer yellow in front, including the very low vertical tubercle; posterior vertex with a narrow dark-brown central line.

Pronotal scutum light-gray, with three brown areas; scutellum light-yellow, with a brown lateral spot. Mesonotal præscutum gray with four conspicuous brownish gray stripes that are narrowly bordered by dark brown, humeri dusky; scutum light-gray, each lobe with two confluent brownish gray areas

that are bordered by dark brown; scutellum and mediotergite gray with a very conspicuous brownish black central vitta; pleurotergite gray dorsally, the katapleurotergite more yellowed; vestiture of thorax long and conspicuous, yellow, especially long on sides of mediotergite. Propleura dark brown; mesepisternum gray, mesepimeron and metapleura more yellowed; ventral meral area darker. Halteres with stem obscure yellow, knob dark brown. Legs with coxæ and trochanters yellow; in male, femora black, narrowly yellowed basally, with a vague obscure yellow subterminal ring, tibiæ and tarsi black; claws simple; in female, femora more uniformly brownish yellow, tips broadly blackened. Wings yellow, conspicuously patterned with pale brown and darker brown in a tesselated or zigzag pattern; stigma chiefly yellow, outer end dark brown; somewhat darker clouds at outer end of cell 1st M_2 and at midlength of vein Cu; beyond the cord the yellow ground includes a narrow band beyond stigma and clear marginal spots in centers of cells R_2 to M_4, the last small, in the anal cells these spots much larger; basad of cord the principal ground areas occupy the bases of cells R to 2nd A; a very irregular band beyond level of origin of Rs, completely crossing the wing, in cell M forming a V-shaped area with the point directed basad; veins brown. Veins unusually glabrous, beyond cord lacking on R_{1+2} except at base, R_{2+3}, R_3, M_4 and Cu_1; R_{4+5} and M_1 with trichia on about the outer two-thirds, much fewer on M_2; lacking on veins before cord except the outer end of 2nd A. Venation: R_{1+2} entire; Rs about two and one-half times m-cu; petiole of cell M_1 shorter than m; m-cu at or shortly before fork of M.

Abdominal tergites orange, proximal five segments with a brown middorsal stripe, very broad on first segment, much narrowed or lacking on the intermediate segments; lateral margins gray, bordered internally by a darkened line; tergites six and seven black, posterior borders narrowly yellow, remaining segments brown, telescoped within the preceding segments, the eighth visible only on sides; sternites light yellow, outer segments light brown. Ovipositor with cerci fleshy, orange, long-triangular, tips pointed, hypovalvæ black. Male hypopygium (Plate 3, fig. 28) with the tregite, *t*, transverse, posterior border with broad lateral sections, the margins with long coarse black setæ; central area normally protruding but in slide mounts forced backward so as to appear sunken, as shown; apex bilobed, each lobe tipped with short black spinoid setæ. Ninth sternite a very

low cushion, provided outwardly with a few coarse black setæ. Outer dististyle, *d*, unusually narrow, as compared with *marmoratipennis;* gently curved, apex with four or five blackened spinoid setæ, the outermost larger; inner style blackened outwardly, including the slender slightly upcurved beak; lower beak a rounded paler cushion, densely covered with appressed reddish setæ directed outwardly. Phallosome, *p*, a broad subtriangular yellowish shield. Eighth sternite broad, posterior border on either side with a rounded lobe provided with abundant long yellow setæ; intermediate pale area with more delicate setæ, the outer ones becoming very small and finally appearing as microscopic blackened points near the margin.

Habitat.—Pakistan; India (Kumaon).

Holotype, male, Ukhal, Pauri Garhwal, Kumaon, altitude 9,000 to 9,800 feet, May 12, 1958 (*Schmid*). Allotopotype, female, pinned with type. Paratypes, 1 male, Badrinath, Pauri Garhwal, altitude 10,160 to 11,000 feet, June 18, 1958; 1 male, Tarsali, Pauri Garhwal, altitude 6,000 to 7,000 feet, May 7, 1958; 1 female, Barasu, Pauri Garhwal, altitude 5,000 to 6,000 feet, May 5, 1958; 1 male, Khoghozi, Chitral, Pakistan, altitude 5,180 feet, October 5, 1954 (*Schmid*).

Tipula (*Lunatipula*) *stylostena* is generally similar to *T.* (*L.*) *marmoratipennis* Brunetti, of the Himalayan region, differing evidently in the coloration of the wings but especially in the structure of the male hypopygium. In the latter species the outer dististyle is very broad, especially outwardly, and the inner style is quite different in conformation. I have re-described the types of *marmoratipennis* in another paper [Rec. Indian Mus. **44** (1942) 49–50, fig. 9].

TIPULA OCTACANTHA sp. nov. **Plate 1, fig. 4; Plate 3, fig. 29.**

Size medium (wing of male 15 millimeters); general coloration of thorax ferruginous or orange, pleura more yellowed; antennæ relatively short, flagellar segments bicolored; femora and tibiæ yellowish brown, tips narrowly darkened, claws toothed; wings weakly darkened, unmarked except for the stigma, squama naked, vein R_{1+2} entire; abdomen brownish yellow, subterminal segments blackened to form a ring; male hypopygium with the tergite deeply emarginate, lobes subacute; a single dististyle, strongly armed with spines, including one on disk and a trispinous outer basal lobe.

Male.—Length, about 14 millimeters; wing, 15; antenna, about 3.3.

Frontal prolongation of head brownish yellow; nasus elongate, with long black setæ; palpi yellowish brown, terminal segment elongate, light brown. Antennæ relatively short; yellow, flagellar segments beyond the first bicolored, light yellow, the basal enlargements dark brown; segments weakly incised, longer than the verticils; terminal segment yellow, about twice as long as broad, tipped with a few long black setæ. Head light gray; vertical tubercle deeply divided by a median impression, the lobes thus formed yellow, the color extended forward between the antennal bases and laterad to the eye.

Pronotum darkened medially, light yellow on sides. Mesonotum almost uniformly ferruginous or orange, præscutum almost glabrous, the setæ short and very sparse. Pleura and pleurotergite more yellowed, unpatterned. Halteres with stem yellow, knob dark brown. Legs with coxæ orange yellow; trochanters yellow; femora and tibiæ yellowish brown, brighter basally, tips narrowly darkened; tarsi dark brown, passing into black; legs long and slender, especially the basitarsi which exceed the tibiæ (posterior legs, tibia 14 millimeters, basitarsus 15.5); claws of male toothed. Wings (Plate 1, fig. 4) very weakly suffused, prearcular and costal fields more yellowed, cell Sc slightly darker; stigma oval, brown; obliterative areas restricted in size; veins brown, more yellowed in the brightened fields. Macrotrichia on most longitudinal veins beyond cord, lacking on R_{1+2}, sparse on M_4; basad of cord with complete series on Sc, lacking on both anal veins, sparse and widely scattered over the whole length of M, a few near outer end of main stem of Cu_1; squama naked. Venation: R_{1+2} entire; Rs slightly angulated at base, only a little longer than m-cu; cell 1st M_2 short-pentagonal; petiole of cell M_1 more than one-third the cell and more than twice m; m-cu just beyond fork of M_{3+4} on M_4; cell 2nd M_2 relatively narrow.

Basal abdominal segment fulvous yellow, on the second and succeeding segments more brownish yellow, darker sublaterally, margins yellowed; sternites yellow; segments seven and eight uniformly blackened, hypopygium brownish yellow. Male hypopygium (Plate 3, fig. 29) with the tergite, *t*, transverse, narrow, posterior border with a deep U-shaped notch with a low triangular lobe or tooth at its base, lateral lobes narrowly obtuse at tips; setæ small and sparse, especially near the outer margins.

Ninth sternite a rounded lobe with long yellow setæ. Basistyle with outer angle slightly produced, provided with long yellow setæ. Dististyle, *d*, single, much larger than the basistyle, the body flattened, unusually glabrous, especially the dorsal crest; beak and lower beak obtuse, the latter blackened, just below it on margin with a narrower yellow lobe provided with long yellow setæ, this latter structure presumably representing the almost fused outer style; outer basal lobe very large and complex, stout basally, forking into an acute spine and a stouter arm that again divides into two unequal spines, the shorter outer one with two very small appressed spinules on lateral face; apex of outer basal lobe with sparse very long yellow setæ on bases of all spines; on disk of style near base of outer basal lobe with a further still larger slender spine, making a total of four major spines on each dististyle. Ædeagus simple, surrounded by pale membrane but without distinct gonapophyses. Eighth sternite, *8s*, damaged on posterior margin, with a flattened fingerlike lobe provided with very long yellow setæ, much longer on outer margin.

Habitat.—Sikkim.

Holotype, male, Teng, altitude 4,600 feet, May 12, 1959 (*Schmid*).

Tipula octacantha is readily told by the somewhat peculiar structure of the male hypopygium, particularly the strongly armed dististyle. In its general appearance it suggests *T. brunnicosta* Brunetti, but is quite distinct. At the present time I do not think it advisable to try to place the species in a subgeneric group.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *d*, dististyle; *g*, gonapophysis; *p*, phallosome; *s*, sternites, *t*, tergites.]

Plate 1

Fig. 1. *Tipula* (*Schummelia*) *dravidiana* sp. nov.; venation.
2. *Tipula* (*Indotipula*) *melacantha* sp. nov.; venation.
3. *Tipula* (*Oreomyza*) *lætabunda* sp. nov.; venation.
4. *Tipula octacantha* sp. nov.; venation.
5. *Tipula* (*Bellardina*) *savtshenkoi* sp. nov.; male hypopygium.
6. *Tipula* (*Schummelia*) *appendifera* Alexander; male hypopygium.
7. *Tipula* (*Schummelia*) *argentacea* sp. nov.; male hypopygium.
8. *Tipula* (*Schummelia*) *argentosigna* sp. nov.; male hypopygium.
9. *Tipula* (*Schummelia*) *atrosetosa* sp. nov.; male hypopygium.
10. *Tipula* (*Schummelia*) *dravidiana* sp. nov.; male hypopygium.
11. *Tipula* (*Schummelia*) *fuscocellula* sp. nov.; male hypopygium.
12. *Tipula* (*Schummelia*) *nannaris* sp. nov.; male hypopygium.
13. *Tipula* (*Schummelia*) *tanyrhina* sp. nov.; male hypopygium.

Plate 2

Fig. 14. *Tipula* (*Yamatotipula*) *bhoteana* sp. nov.; male hypopygium.
15. *Tipula* (*Yamatotipula*) *hexacantha* sp. nov.; male hypopygium.
16. *Tipula* (*Nobilitipula*) *specularis* sp. nov.; male hypopygium.
17. *Tipula* (*Acutipula*) *echo* sp. nov.; male hypopygium.
18. *Tipula* (*Acutipula*) *hemmingseniana* sp. nov.; male hypopygium.
19. *Tipula* (*Indotipula*) *melacantha* sp. nov.; male hypopygium.
20. *Tipula* (*Indotipula*) *pandava* sp. nov.; male hypopygium.
21. *Tipula* (*Indotipula*) *prolata* sp. nov.; male hypopygium.

Plate 3

Fig. 22. *Tipula* (*Vestiplex*) *rhimma* sp. nov.; male hypopygium.
23. *Tipula* (*Vestiplex*) *eurydice* sp. nov.; male hypopygium.
24. *Tipula* (*Vestiplex*) *siddartha* sp. nov.; male hypopygium.
25. *Tipula* (*Oreomyza*) *lætabunda* sp. nov.; male hypopygium.
26. *Tipula* (*Oreomyza*) *guttulifera* sp. nov.; male hypopygium.
27. *Tipula* (*Oreomyza*) *sordidipes* sp. nov.; male hypopygium.
28. *Tipula* (*Lunatipula*) *stylostena* sp. nov.; male hypopygium.
29. *Tipula octacantha* sp. nov.; male hypopygium.

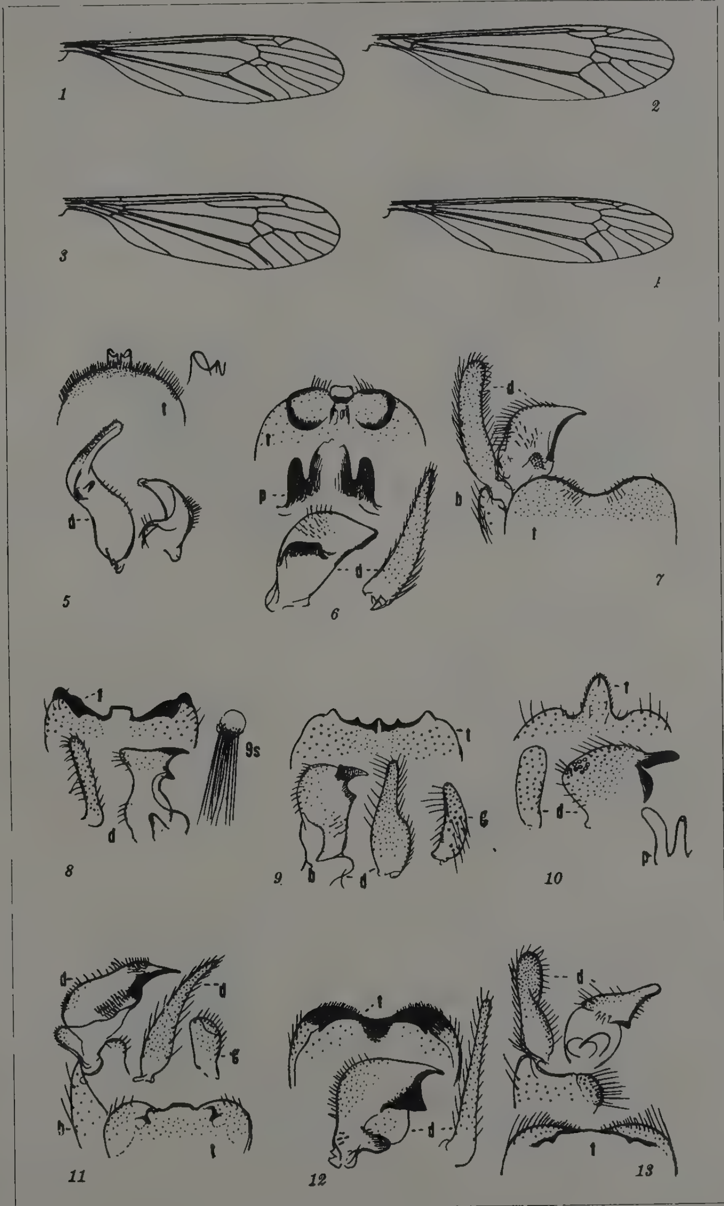
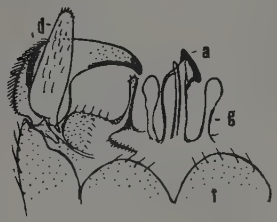
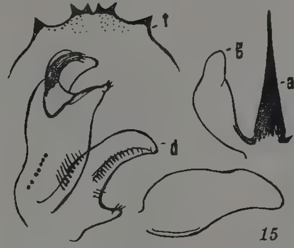


PLATE 1.



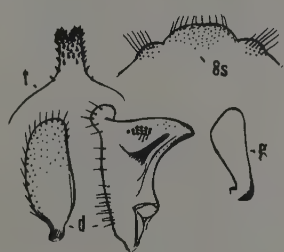
14



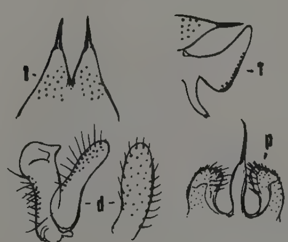
15

16

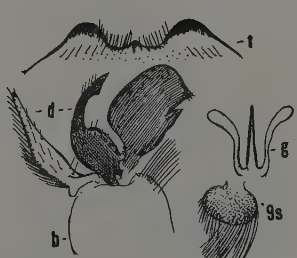
17



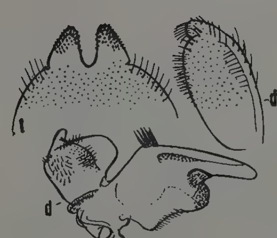
18



19

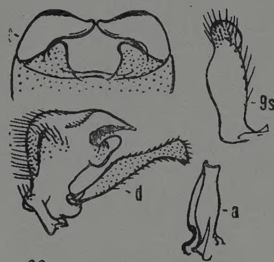


20



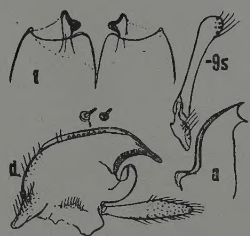
21

PLATE 2.



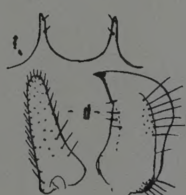
22

23

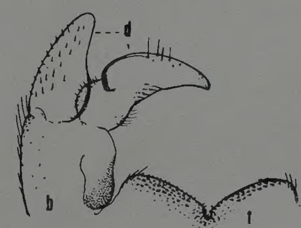


24

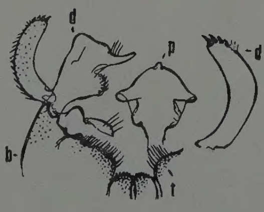
25



26



27



28

29

PLATE 3.

PUBLICATIONS AVAILABLE

CONTENTS AND INDEX. THE PHILIPPINE JOURNAL OF SCIENCE, vol. 1 (1906) to vol. 10 (1915). Bureau of Science Publication No. 8 (1917). Paper, 442 pages. Price, $2.00 United States currency, postage extra.

SECOND TEN-YEAR INDEX. THE PHILIPPINE JOURNAL OF SCIENCE, vol. 11 (1916) to vol. 28 (1925). Compiled by Winifred I. Kelley. Bureau of Science Monograph 26. Paper, 382 pages. Price, $2.00 United States currency, postage extra.

CHECKLIST OF THE ANTS (HYMENOPTERA: FORMICIDÆ) OF ASIA. By J. W. Chapman and S. R. Capco. Institute of Science and Technology Monograph 1 (1951) new series. Paper, 327 pages. Price, $2.00 United States currency, postage extra.

NOTES ON PHILIPPINE MOSQUITOES, XVI. GENUS TRIPTEROIDES. By F. E. Baisas and Adela Ubaldo-Pagayon. Institute of Science and Technology Monograph 2 (1952) new series. Paper, 198 pages with 23 plates and 4 text figures. Price, $2.50 United States currency, postage extra.

NOTE TO CONTRIBUTORS

Manuscripts intended for publication in the Philippine Journal of Science should be sent to the Editor, Philippine Journal of Science, National Institute of Science and Technology, Manila, Philippines.

The Journal will not be responsible for the loss of unsolicited manuscripts, but those received will be acknowledged and considered promptly by the Board of Editors or other competent critics. Authors will be notified of the decision reached as soon as possible.

Manuscripts on biology must be accompanied by abstracts for publication in the biological abstracts.

Manuscripts submitted should be typed on one side of white bond paper, 8½" × 11", and double-spaced throughout. One original copy and one carbon copy of manuscripts should be submitted.

Illustrations should accompany manuscripts on separate sheets. Photographs should be sent unmounted, with serial number written on back to correspond with list of captions.

Fifty separates of each paper published in the Journal are furnished free to an author (in case of more than one author, this number is to be divided equally). Additional copies may be had at the author's expense if ordered at the time the manuscripts is submitted for publication.

The Philippine Journal of Science is published quarterly, the subscription rates per year being: Philippines, U.S. $5.00; Foreign, U.S. $8.00, including postage. Single issues are U.S. $1.25 in the Philippines and U.S. $2.00 in foreign countries.

Subscriptions to the Journal should be sent to the Business Manager, Philippine Journal of Science, National Institute of Science and Technology, Manila, Philippines.

Publications sent in exchange for the Journal should be addressed to the Division of Documentation, National Institute of Science and Technology, Manila, Philippines.

CONTENTS